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Public Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 10, October 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Environmental Control Administration • National Center for Radiological Health

Reports

A Pilot Survey of X-radiation Emissions from Color Television Receivers in Pinellas County, Florida

Technical Services Branch, National Center for Radiological Health

A pilot survey was conducted in Pinellas County, Florida, in November 1967 to evaluate methodology and techniques for use in determining the effectiveness of General Electric Company's modification program of color television receivers and in assessing the total radiation emission situation for television sets of all manufacturers. The instrument used was designed by the National Center for Radiological Health to facilitate rapid home surveys. To further document the source, size, shape and intensity of emissions, radiographic films were exposed on selected receivers.

The primary object of this survey was to evaluate the effectiveness of the downward beam modification program. Within the limits of this survey, the General Electric Company's downward beam modification program was found effective. The initial survey determined that 43 of the 148 sets had x-ray emissions in excess of 0.5 mR/hr; after modification, all sets emitted less than 0.5 mR/hr. A second object of the survey was to evolve and test new instruments and new methods of measurement for a future survey of television sets produced by all manufacturers.

In the spring of 1967, the General Electric Company undertook a program to modify approximately 110,000 large-screen color television receivers by replacement of high-voltage shunt regulator tubes. The object of the modification program was to correct a downward emission of x radiation emanating from the high-voltage shunt regulator tube. The Company reported that practically all of the sets had been modified by the summer of 1967.

Following notification of the problem and of the modification program by the General Electric Company, the Public Health Service (PHS) investigated the radiation emission from regulator tubes used in color television receivers (*1*, *2*). The studies described the measured x-ray distributions in direction, quality and intensity from the shunt regulator tube.

[1] The film dosimetry packs contained two 14x17 inch films, one of high sensitivity for recording low radiation doses and the other of a lower sensitivity for recording higher doses.

The PHS indicated to the House Subcommittee on Public Health and Welfare of the House Committee on Interstate and Foreign Commerce (*3*) and to the Senate Commerce Committee (*4*) that the effectiveness of the modification program should be verified through laboratory and field tests by the National Center for Radiological Health (NCRH). This report describes participation of the NCRH with the Pinellas County (Florida) Health Department in a pilot survey conducted in November 1967.

Survey design

The NCRH made arrangements in October 1967 with the Pinellas County Health Department to conduct a joint survey to test the methods and procedures required for radiation surveys of home color television receivers. Pinellas County, Fla. was selected as the site for the survey because of the county's special

interest in the problem and previous efforts to achieve control over the x-ray emissions from television receivers. The specific objectives of the survey were: (1) to check the results of the modification program carried out by the General Electric Company on certain large-screen color television sets in Pinellas County; (2) to evaluate methodology and techniques applicable to a more extensive evaluation of the downward beam from shunt regulator tubes; and (3) as far as possible, to develop techniques for the assessment of the total radiation emission situation for sets of all manufacturers.

The manufacturer had distributed color television sets in Pinellas County potentially capable of emitting x rays in excess of the 1960 recommendation of the National Council of Radiation Protection. The recommendation states that "the exposure rate at any readily accessible point 5 cm from the surface of any home television receiver shall not exceed 0.5 mR/hour under normal operating conditions." The Company had modified those color television sets already purchased by having local servicemen replace the high-voltage shunt regulator tubes (type 6EA4, 6EF4, or 6LC6) originally in the receivers with improved tubes (type 6EH4, 6EJ4, or 6LH6) and readjust the regulated high-voltage supply to the cathode ray tube. The service representatives were not equipped to measure x-ray emission.

Estimates of the x-radiation exposure rates from the television receivers in the home were obtained by a large-area Geiger-type survey meter scan of the exterior surfaces of the set. To further document the source, size, shape and intensity of emissions, radiographic films[1] were exposed on one or more surfaces of selected receivers having radiation emissions above 0.5 mR/hr. Later in the survey, film was used only on sets having emission rates above 2.5 mR/hr. The films were then sent to the NCRH headquarters in Rockville, Md., where they were developed and analyzed by visual and optical density measurements. A detailed description of the procedure is given in an earlier report (*5*).

The manufacturer's technical personnel who accompanied the survey teams provided technical assistance and followup, including the adjustment of operating high voltage and the replacement of receiving tubes when this was necessary to reduce x-ray emission. The shunt regulator tubes in each receiver were replaced by an improved version of the tube designated 6EH4A, 6EJ4A or 6LH6A as appropriate to each individual set. The appropriate tube replacement and/or proper high-voltage adjustment reduced the radiation to an acceptable level in all cases. This exchange program provided the NCRH with a sample of the tubes for use in laboratory tests.

Instrumentation

The instrument used in the survey was designed and constructed expressly for surveying radiation from television receivers (*6*) and received its initial field test in Pinellas County. The radiation-sensitive element of this instrument is an array of six Victoreen type 1B85 Geiger-Mueller counters. They are connected to a common high-voltage supply. Individual solid state circuits measure the current through each counter. The outputs of these counter readout circuits are connected to the input of the circuit in such a manner that the meter indicates only the reading of the counter with the highest output. This connection has the sensitive area of one counter for calibration. The large sensitive detection area provided by the six tubes allowed a surveyor to make a complete traverse of all set surfaces in 10 minutes. The instrument was easily handled in any position by one person. The location and approximate size of radiation beams could be estimated by depressing a switch which turned off all detector tubes except the end one.

Since the primary objective of the survey was to check the results of the modification program, instruments were calibrated using a downward emission from a shunt regulator tube. Using this calibration, a meter reading of 4,000 on the instrument is equivalent to 0.5 milliroentgen per hour (mR/hr).

During the initial survey operation, current leakage across the bases of the G-M survey counters, due to humidity, caused high background counting rates. The problem was solved by thoroughly drying the bases of the 1B85 detectors and encapsulating them with silicone rubber.

Survey procedures

The necessary local arrangements for visits to the set owners were made by the Pinellas County Health Department. All known modified receivers in the county were listed in alphabetical order by name of the owner and each set was assigned a code number. An introductory letter issued by the County Health Department was sent to each owner describing the purpose of the survey. Appointments were arranged in advance by telephone. When set owners could not be reached by telephone, the survey teams called in person.

Surveys of television receivers in homes were conducted by three teams. Each team consisted of a representative of the Public Health Service, Pinellas County, and the manufacturer. On entering the home, the householder was asked to turn the set on and obtain a normal picture. The manufacturer's representative observed the picture and determined whether the set operation appeared normal. The team surveyed the set on all sides, top, and bottom, for x-ray emissions. Succeeding steps depended upon the conditions found, which were classified into one of four categories as follows:

Condition 1—set operation appears normal—instrument reading less than 4,000:

(1) serviceman measured line voltage, survey of set was made, and team leader recorded meter readings;
(2) serviceman replaced shunt regulator tube and adjusted anode voltage;
(3) team leader recorded tube types and properly identified old tubes with the set;
(4) set was turned on and readjusted;
(5) a resurvey was made and meter readings noted on report forms.

Condition 2—set operation appears normal—instrument reading at or above 4,000:

(1) serviceman measured line voltage;
(2) team leader made judgment on use of film after consultation with owner;
(3) when used, film was applied by tape to the identified area or areas of maximum emission. Film was identified by set code number;
(4) when film was used, a cumulative timer was connected to record set operating time, or arrangements were made with the owner to operate the set continuously for sufficient time to deliver an estimated minimum of 10 mR to the film. Films were removed at a prearranged time by the team;
(5) serviceman measured line voltage and anode voltage, replaced tube(s) identified as source(s) of emission, reset anode voltage and readjusted picture;
(6) team leader resurveyed the set and recorded the information.

Condition 3—set operation appears abnormal—instrument reading less than 4,000:

(1) serviceman designated the probable cause of any malfunction,
(2) team leader asked the owner to observe the picture, asked whether he had noticed any difficulty, whether he regularly used the set, and whether the set had been repaired or adjusted since the modifications were completed
(3) the survey was continued as for Condition 1.

Condition 4—Set operation appears abnormal—instrument reading at or above 4,000:

(1) proceeded per (1) and (2) under Condition 3;
(2) proceeded per (1) through 6) under Condition 2
3) in the event that instrument readings above 4,000 were measured after completing the survey, the team leader advised the owner that servicing was needed and recommended distances and viewing positions to limit radiation exposure. After servicing was reported by owner as having been completed, a resurvey of the set was made.

In some instances measurements were also made with the set brightness adjusted to the darkest usable picture to indicate whether the shunt regulator tube was the primary source of radiation.

It took approximately 30 minutes to complete a survey of a set. The visits were arranged so that the teams were working within a small geographical area of the county at any given time. This kept travel time between surveys at a minimum. Each survey team, working full time, was able to complete approximately seven surveys per day.

Information recorded

For each set the model number and serial number were recorded. In addition to the radiation levels measured for each set, estimates of the size of the radiation field and location of the center of the radiation field on the set surfaces were entered on the survey form. Information concerning the date of modification and any servicing since modification was recorded. For each set a determination and record was made by the team leader as to whether survey instrument readings from the set were below 4,000. Where film packs were used, the film pack identification number and the exposure time were recorded.

The Public Health Service personnel participated in surveys of 143 sets and the county personnel completed surveys of five additional sets. Ten other sets could not be surveyed for the following reasons: one refusal, eight sets could not be located or had been moved from the county, and one set was returned for service and repair. The sets surveyed included four "B" model chassis and one "D" model chassis. These are models of color television sets which were not included in the Company's modification program.

Using the instrument calibration and certain assumptions (*5*), the recorded data were converted to mR/hr and are presented in tables 1 and 2. Table 1 shows the number of color television receivers by x-radiation exposure rate and operating high voltage. The line voltage was found to vary from 110 to 127 volts. The anode voltages measured ranged from 19 kV, d.c. to over 30 kV, d.c. (the shunt regulator tube voltage is about 400 volts, d.c. lower). The location of maximum x-radiation exposure rates on home color television receivers is shown in table 2.

Summary of findings

(1) There were no detected instances of either downward or frontward emitted radiation in excess of 0.5 mR/hr. Where levels of emission were detected, they appeared to be from a component source within the receiver that could be associated with the sets of all manufacturers (*6*).

(2) The location of radiation leakage on the television receivers indicated that x rays from the high-voltage rectifier tube as well as from the shunt regulator tube was a significant factor. Patterns identified by photographic film exposed on a selected number of television receivers suggest the rectifier tube as a probable primary source of lateral x-ray emission.

(3) It was observed that the operating high voltage in the majority of the sets surveyed

Table 1. Number of color television receivers by x-radiation exposure rate and operating high voltage

X-radiation exposure rate (mR/hr)	Operating high voltage (kilovolts)											Total sets
	21	22	23	24	25	26	27	28	29	30	Unknown	
<0.040	3	6	4	16	15	3	—	—	—	—	7	54
0.040–<0.075	—	—	1	2	1	1	—	—	—	—	—	5
0.075–<0.125	—	—	—	—	—	2	—	—	—	—	—	2
0.125–<0.25	—	—	—	6	12	2	1	—	—	—	—	21
0.25 –<0.50	—	—	3	6	12	1	—	—	—	—	1	23
0.50 –<1.00	—	—	—	3	6	7	3	—	—	—	2	21
1.00 –<2.00	—	—	—	4	7	2	—	1	—	—	1	15
2.00 –<3.75	—	—	—	1	—	—	—	—	—	—	—	1
3.75 –<7.50	—	—	—	1	2	—	1	—	—	—	—	4
7.50 –<12.50	—	—	—	—	—	—	—	—	—	—	—	—
≥12.50	—	—	—	—	—	—	—	—	1	1	—	2
Total	3	6	8	39	55	18	5	1	1	1	11	148
Percent exceeding 0.5 mR/hr	—	—	—	23.1	27.3	50.0	80.0	100.0	100.0	100.0	27.3	29.1

Table 2. Location of maximum x-radiation exposure rates on home color television receivers

X-radiation exposure rates (mR/hr)	Number of sets by location of the highest exposure rate measurement [a]						Total sets
	Bottom	Left	Top	Front	Right	Back	
0.040– <0.075	—	2	—	—	—	3	5
0.075– <0.125	—	1	—	1	—	—	2
0.125– <0.25	—	17	—	1	—	3	21
0.25 – <0.50	—	18	1	—	—	4	23
0.50 – <1.00	—	18	—	—	—	3	21
1.00 – <2.00	—	11	—	—	—	4	15
2.00 – <3.75	—	1	—	—	—	—	1
3.75 – <7.50	—	4	—	—	—	—	4
7.50 – <12.5	—	—	—	—	—	—	—
≥12.5	—	2	—	—	—	—	2
Total	—	74	1	2	—	17	94

[a] A number of sets had the same exposure rate on more than one side. The priority for placement in the table is the following: front, left, top, back, bottom, and right. "Left" is the set surface on the viewer's left.

was above the value recommended by the manufacturer at the line voltage encountered. Since an extensive modification program had been performed in Pinellas County and instructions had been given to the repairmen on the proper voltage setting, it was not expected that these high operating voltages would be found. Therefore, high operating voltages may be a major cause of the high emission rates from the high-voltage rectifier tube. The effect on the x-ray emission of varying the high voltage of the rectifier is illustrated in table 3. It was also noted that in many cases x-radiation emission was reduced when the high voltage was adjusted to the level recommended by the manufacturer. Laboratory tests conducted by the NCRH have shown that excessive operating voltage can result in x-radiation emissions from tube components (*1, 2*).

Table 3. X-ray exposure rates from a rectifier tube at various voltages

Kilovoltage (kV)	X-ray exposure rates (mR/hr)
27	10
26	5
25	3
24	1
23	0.35

(4) A resurvey of the sets showed all sets to be within the recommended level after a service adjustment was made to each set in Pinellas County that had an x-ray emission above the recommended level of 0.5 mR/hr. This adjustment included exchange of the shunt regulator tube, exchange of the high-voltage rectifier tube, and adjustment of the operating high voltage. Appropriate tube replacement and proper high-voltage adjustment reduced x radiation to an acceptable level in all cases.

(5) Incidental to the survey, a 6EA4 tube was found in a "B" model chassis. This is a different model of the General Electric television receiver from those included in the GE modification program. A radiation level in excess of 12.5 mR/hr was observed at the side of the set to the viewer's left. An exchange of the shunt regulator tube and a voltage adjustment corrected this radiation problem.

Conclusions

(1) In the sets surveyed, the problem of downward directed x-ray leakage had been corrected by replacement of the original high-voltage shunt regulator tubes (type 6EA4, 6EF4, 6LC6) with replacement tubes (6EH4, 6EJ4, or 6LH6) and in the later stages of the modification program, the "A" version of these tubes. The review of the survey reports of 148 sets showed that within the limits of the survey instrument used, only two sets had a measurable radiation level at the bottom of the set. These levels were below the meter reading of 4,000.

(2) The high-voltage rectifier appeared to be the major source of radiation. In many cases the emission was due in part to a high-voltage setting greater than that recommended by the manufacturer.

Acknowledgments

Arrangements for the survey were made by George McCall, public health physicist, Pinellas County Health Department, and Mr. D. J. Nelson, Jr., assistant to the director for laboratories, National Center for Radiological Health. Mr. Nelson served as the overall director of the project. Members of Mr. McCall's staff, Mr. Clyde Stagner and Mr. Dale Rees, served as the survey team leaders. Mrs. Russell Hobbs, Pinellas County Health Department, arranged the appointments for the surveys in the homes. Mr. Roger Schneider, Electronic Products Radiation Laboratory, was the project coordinator for the NCRH in Pinellas County, and Mr. Donald Smith, Technical Services Branch, NCRH, was the project officer.

The necessary local arrangements for visits to the set owners were made by Dr. John T. Obenschain, director, Pinellas County Health Department, and Mr. George McCall, public health physicist, Pinellas County Health Department.

The instrument used in the survey was designed and constructed by Mr. Richard K. Stoms and Mr. Edward Kuerze, National Center for Radiological Health, Cincinnati, Ohio.

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A Summary of the Washington, D.C. Metropolitan Area Survey of Color Television Receivers

Technical Services Branch, National Center for Radiological Health

A survey was conducted by the National Center for Radiological Health (NCRH) during December 1967 and January 1968 with the cooperation of the Electronic Industries Association and individual manufacturers to obtain x-ray emission data from color television receivers owned by Public Health Service employees in the Washington, D.C. area. Radiation measurements, using a survey instrument developed by the NCRH, were made on 1,124 color television sets of various makes and models. Of these sets, 66 emitted x rays at exposure rates were at or in excess of the recommended level of 0.5 mR/hr. The x-ray emissions were reduced to acceptable levels through service adjustments, such as replacement of shunt regulator or rectifier tubes and reduction of the operating high voltage. The survey results are considered to be valid only for the sample of sets examined in the Washington, D.C. area.

The Public Health Service announced in May 1967 that the General Electric Company had sold certain large-screen color television sets, produced between June 1966 and February 1967, which had the potential of emitting higher than desirable levels of x rays (*1*). The source of the problem was a defective high-voltage shunt regulator tube. The Company undertook to correct the approximately 110,000 affected sets through a nationwide modification program based upon a replacement of the faulty tubes.

During Congressional hearings in the summer and fall of 1967, the Public Health Service indicated that the effectiveness of the Company's modification program would be verified through laboratory and field tests (*2*). The x-ray emission characteristics of shunt regulator tubes and other high-voltage components were investigated in two National Center for Radiological Health (NCRH) laboratories (*3–5*). A joint pilot survey was also undertaken by the Center with the Pinellas County (Florida) Health Department to check the results of the General Electric Company modification program in that County (*6, 7*). As a result of these investigations, radiation emissions observed from sources other than the shunt regulator tube indicated a potential industry-wide problem.

To obtain additional information, an x-ray survey was developed for a sample of color television sets owned by Public Health Service employees in the Washington, D.C. metropolitan area. The purpose of the survey was to obtain x-ray emission data for television receivers of all the manufacturers included in the sample. The survey, conducted by the National Center for Radiological Health during December 1967 and January 1968, had the active cooperation of the Electronic Industries Association and individual manufacturers.

The following is a summary of information contained in the report, "A Survey of X-radiation from Color Television Sets in the Washington, D.C. Metropolitan Area," by the Technical Services Branch, dated March 12, 1968. A full description of the methodology and measurement techniques employed and an evaluation of the data is presented in the complete report.

The survey

The objectives of the survey were: (1) to obtain x-ray emission data on a variety of makes and models of color television sets operating in the Washington area, (2) to test procedures for, and to determine the feasibility and usefulness of more representative and ex-

tensive surveys of color television receivers, and (3) to provide information on possible sources of x radiation which could be used by manufacturers or service organizations to prevent or correct excessive x-radiation emissions. The basis for determining whether x-ray levels were excessive was the 1959 National Council on Radiation Protection and Measurements (NCRP) recommendation ". . . that the exposure rate at any readily accessible point 5 cm. from the surface of any home television receiver shall not exceed 0.5 mR per hour under normal operating conditions" (*8*).

Public Health Service employees in the Washington, D.C. area were asked to make available their color receivers for radiation measurements. A total of 1,124 sets were surveyed. These comprised a variety of brand names and models from 20 domestic and five foreign manufacturers. Representatives from these manufacturers and from two retail distributors provided technical support for surveys involving their particular sets.

Visits to homes to obtain x-ray emission measurements and other essential data were begun on December 16, 1967. Survey teams, composed of Public Health Service and industry representatives, visited an average of seven homes per day. As many as nine teams were in the field at any one time during the survey.

The Public Health Service representatives made the radiation measurements, recorded data, and interviewed the set owner. The industry personnel assisted in identifying the color receivers and components and in measuring household line voltages and receiver operating high voltages. Where necessary, the industry representatives also made corrections so that the sets conformed to the NCRP recommendation.

X-ray emission measurements were made using a survey instrument developed by the NCRH Electronic Products Radiation Laboratory (*9, 10*). This Geiger-Mueller-type instrument was designed and constructed expressly for the purpose of rapidly and accurately obtaining in-home measurements of color television x-ray emissions.

For the purpose of the Washington survey, the survey instrument was calibrated with an x-ray beam from a 6EF4 shunt regulator tube operated at 25 kV, d.c. between the anode and cathode. This beam uniformly irradiated the detector at exposure rates between 0 and 12.5 mR/hr. The exposure rates for the calibration x-ray beam were determined by a Victoreen model 440 RF Survey Meter; this secondary system had been calibrated by means of a General Electric Maximar 100 self-rectified therapy x-ray machine and a Victoreen type 326, 10 roentgen ionization chamber having National Bureau of Standards calibration for lightly filtered x rays. The energy response of the 440 RF was essentially independent for the x-ray spectrum under consideration. The beam had a first half-value layer of 0.5 mm of aluminum. A level of 0.04 mR/hr was the minimum exposure rate that could be detected by the survey instrument.

Each set was operated in a condition as normally viewed and radiation measurements were made at 2 inches from all outer surfaces. The exposure rates determined in this manner were compared with the NCRP recommendation.

If a set was emitting in excess of 0.5 mR/hr, an attempt was generally made to use radiographic film (*11*) as a supplementary survey technique. The film measurements provided additional information on the exposure rate, size, shape, and possible source of the x-ray emission. The film technique was also used in some cases to study situations where emission levels were less than 0.5 mR/hr as determined with the survey instrument.

Limited information on viewing habits was obtained through discussion with household members while the survey measurements were being made. In order to avoid extension of the time required for home visits, the use of a questionnaire or the formal interview technique was not employed.

Results

Radiation emission was detectable from a variety of makes and models of 1,124 color television receivers surveyed (see table 1). Table 2 gives the distribution of color television receivers by the highest x-radiation exposure rates as measured by the NCRH survey instrument under home operating conditions. X-radiation emissions were not detected from 856

Table 1. X-radiation emission from color television receivers

Receiver name	Sets surveyed	Sets with x radiation at or above 0.04 mR/hr [a]	Sets with x radiation at or above 0.5 mR/hr [b]
RCA	360	78	20
Zenith	162	58	19
Sylvania	100	7	0
Motorola	75	32	4
GE	72	5	0
Sears	71	18	1
Magnavox	69	23	10
Philco	45	3	0
Airline	33	13	1
Admiral	30	5	0
Westinghouse	19	1	0
Heath	18	1	0
Dumont	16	0	0
Penncrest	15	3	1
Setchell Carlson	13	13	8
Packard Bell	7	3	0
Muntz	6	1	0
Curtis Mathes	4	0	0
Delmonico	2	2	1
Symphonic	2	2	1
Bradford	2	0	0
Clairtone	1	0	0
AMC	1	0	0
Panasonic	1	0	0
Total	1,124	268	66

[a] The minimum detectable level of the instrument used was 0.04 mR/hr.
[b] 0.5 mR/hr is the maximum exposure rate at any readily accessible point 5 cm from the surface of any home television receiver as recommended by NCRP.

receivers. Exposure rates at or above the 0.04 mR/hr detectable level were recorded for 268 receivers. Of these, 66 sets had x-radiation levels at or above 0.5 mR/hr, 40 indicated levels at or above 1.0 mR/hr and 2 sets exceeded 12.5 mR/hr (the full scale reading of the survey instrument).

For the 268 sets at or above 0.04 mR/hr, x-radiation emissions were observed on six sides of 10 receivers, on five sides of 18 receivers, on four sides of 22 receivers, on three sides of 32 receivers, on two sides of 57 receivers, and on one side of 129 receivers. The highest x-radiation levels for individual sets were measured at the left side for 68 sets, at the back for 74, and at the front for 54 sets. Over 20 percent of the sets with levels greater than 0.04 mR/hr had the highest x-radiation emission from the front.

For the 66 sets with readings at or above 0.5 mR/hr, x-radiation emissions were detected on six sides of 7 receivers, on five sides of 8 receivers, on four sides of 9 receivers, on three sides of 12 receivers, on two sides of 16 receivers, and on one side of 14 receivers.

Table 3 shows the location of the highest x-radiation levels measured on the sets above 0.04 mR/hr. For the 66 sets with emissions equal to or exceeding 0.5 mR/hr, the locations of the highest levels measured were as follows: bottom—11 sets; left (of viewer)—20 sets; top—sets 2; front—sets 12; right (of viewer)—set 1; and back—20 sets.

Table 2. Distribution of color TV receivers by the x-radiation exposure rate

Receiver name [a]	X-radiation exposure rate, mR/hr										
	0.040 to <0.075	0.075 to <0.125	0.125 to <0.25	0.25 to <0.50	0.50 to <1.00	1.00 to <2.00	2.00 to <3.75	3.75 to <7.50	7.50 to <12.50	12.50 and over	Total
Admiral	2	1	0	2	0	0	0	0	0	0	5
Airline	5	1	3	3	1	0	0	0	0	0	13
AMC	0	0	0	0	0	0	0	0	0	0	0
Bradford	0	0	0	0	0	0	0	0	0	0	0
Clairtone	0	0	0	0	0	0	0	0	0	0	0
Curtis Mathes	0	0	0	0	0	0	0	0	0	0	0
Delmonico	1	0	0	0	0	1	0	0	0	0	2
Dumont	0	0	0	0	0	0	0	0	0	0	0
General Electric	1	0	4	0	0	0	0	0	0	0	5
Heath	1	0	0	0	0	0	0	0	0	0	1
Magnavox	1	1	8	3	6	0	1	1	1	1	23
Motorola	7	1	13	7	3	0	1	0	0	0	32
Muntz	0	1	0	0	0	0	0	0	0	0	1
Packard Bell	1	1	1	0	0	0	0	0	0	0	3
Panasonic	1	0	0	0	0	0	0	0	0	0	1
Penncrest	1	0	1	0	0	1	0	0	0	0	3
Philco	0	0	1	2	0	0	0	0	0	0	3
RCA	14	14	18	12	6	9	1	2	2	0	78
Sears	2	6	6	3	1	0	0	0	0	0	18
Setchell Carlson	0	1	3	1	1	1	1	2	2	1	13
Sylvania	4	1	1	1	0	0	0	0	0	0	7
Symphonic	0	0	0	1	1	0	0	0	0	0	2
Warwick	0	0	0	0	0	0	0	0	0	0	0
Westinghouse	0	0	0	0	0	0	0	0	0	0	0
Zenith	11	10	9	9	7	11	1	0	0	0	58
Total	52	38	68	44	26	23	5	5	5	2	268

[a] The manufacturers included in the survey were: Admiral, Clairtone Electric Corporation, Curtis Mathes, Delmonico Japan, Emerson-Dumont, General Electric, Hayakawa, Heath Company, Hoffman Products, Hoffman Electronics, Magnavox, Matshushita, Motorola, Packard Bell, Philco Ford, RCA, Sylvania, Setchell Carlson, Symphonic Electric Corporation, Toshiba, TV Corporation of America, Warwick Electronics, Wells Gardner, Westinghouse, and Zenith.

Table 3. Location of maximum x-radiation exposure rates on home color television receivers

X-radiation exposure rates (mR/hr)	Number of sets by location of the highest exposure rate measurement [a]						
	Bottom	Left	Top	Front	Right	Back	Total
0.040— <0.075	8	7	12	14	0	11	52
0.075— <0.125	6	4	9	11	0	8	38
0.125— <0.25	2	23	14	9	0	20	68
0.25 — <0.50	2	14	4	8	1	15	44
0.50 — <1.00	6	7	2	3	1	7	26
1.00 — <2.00	3	6	0	5	0	9	23
2.00 — <3.75	0	2	0	1	0	2	5
3.75 — <7.50	0	2	0	2	0	1	5
7.50 — <12.50	1	2	0	1	0	1	5
≥12.50	1	1	0	0	0	0	2
Total	29	68	41	54	2	74	268

[a] A number of sets had the same exposure rate on more than one side. The priority for placement in the table is the following: front, left, top, back, bottom, and right. "Left" is the set surface on the viewer's left.

In the survey, 70 film packs were exposed on 55 receivers, 45 of which were found with x-radiation emissions at or above 0.5 mR/hr by the survey instrument. Exposure rates measured by the radiographic film technique ranged from 0.12 to 369 mR/hr as shown in table 4.

Comparison of film pack and survey instrument measurements of x-radiation exposure rates are also shown in table 4. Valid comparisons could be made with survey instrument measurements of exposure rate for 58 of 70 films. The film gave higher values than the instrument in 48 comparisons and lower values in 10 cases.

Data on line voltage and operating high voltage were obtained because of the importance of these parameters in the production of x radiation (*5*). The line voltage measurements ranged from 107 to 129 volts. The line voltage observed most often was 120 volts. The operating high voltage of a receiver can vary with the line voltage depending on the degree of regulation provided by the circuit design. The maximum variation in line voltage can produce a 20 percent change in the operating high voltage of a receiver.

Table 5 shows the operating high voltage measurements on 808 receivers and the x-radiation emissions from these sets by high-voltage intervals of 1 kV over the observed range of 18 kV to 34 kV. Some sets operating well below the observed average high-voltage level emitted excessive x radiation. However, as one would expect, there is a general increase in the proportion of sets exceeding the 0.5 mR/hr x-radiation exposure rate as operating voltages increase.

High-voltage measurements were made on 226 of the 268 sets found to be emitting x radiation at or above 0.04 mR/hr. The average observed high voltage for the 181 receivers having a shunt regulator tube and producing x radiation at or above 0.04 mR/hr was 25.8 kV; the average rated high voltage for these receivers was 24.4 kV. Eighty-two of the 181 receivers exceeded 26.5 kV. For the 45 receivers not having a shunt regulator tube and producing measurable x radiation, 27 had a high-voltage reading above 27 kV which was the average value observed for such receivers.

Table 6 gives the distribution of the highest x-radiation exposure rate measured by the year of purchase. Detectable x radiation was observed regardless of the age of the sets. The survey did not provide detailed information on the amount of servicing, including replacement of components. A service adjustment within the 2-month period prior to the survey was reported for 24 of the 66 sets with exposure rates above 0.5 mR/hr.

The probable sources of x radiation were determined from a review of the instrument measurements and the patterns formed on film. In the 55 sets studied with film, the shunt regulator tube was identified as the probable primary source in 30 of the receivers, the picture tube in nine, a combination of the shunt regulator and picture tube in six, and the rectifier tube in eight other receivers. In two sets, no specific source could be identified.

Each receiver with x-radiation emission above 0.5 mR/hr was serviced by the manufacturer's representative and resurveyed to in-

Table 4. X-radiation emission levels from color TV receivers by location, probable source and operating kilovoltage based on survey instrumentation and radiographic film measurements

Receiver case number [a]	Receiver operating voltage (kV)	Probable source of x-radiation	Location film on receiver	Time of film exposure (hr)	X-radiation exposure rates [b] (mR/hr)	
					Film	Instrument
1a	——	Picture [c]	Left	61.40	0.12	0.10
1b	——	Picture	Right	61.40	.13	.11
1c	——	Picture	Top	61.40	.15	.11
2	27.6	Rectifier	Bottom	30.50	.14	1.10
3a	——	——	Back	[d](29.00)	.15	.14
3b	——	——	Back	(29.00)	.22	.14
4	27.0	Rectifier	Back	(78.00)	.17	.19
5	29.0	Shunt or rectifier	Left	28.40	.17	.62
6	24.0	Picture	Top	(60.00)	.20	.28
7	28.5	Picture	Back	49.50	.22	.60
8	——	Picture	Top	55.50	.33	.10
9	25.5	Rectifier	Left	64.50	.36	.21
10	23.8	Picture	Back	43.20	.43	.83
11	27.0	Rectifier	Back	23.00	.43	.10
12	26.5	Rectifier	Left	30.50	.44	.19
13	24.5	Rectifier	Back	(43.00)	.52	.19
14a	25.0	Shunt	Left	(27.50)	.80	.50
14b	25.0	Shunt	Back	(8.00)	3.65	3.25
15	31.0	Shunt	Back	24.80	.90	1.10
16	26.0	Shunt	Bottom	(63.50)	.92	.88
17a	30.5	Shunt and picture	Top	61.30	1.20	2.25
17b	30.5	Shunt and picture	Left	61.30	3.17	2.25
17c	30.5	Shunt and picture	Back	61.30	12.80	7.50
18	29.0	Shunt	Left	27.50	1.34	.65
19	30.5	Picture	Left	(10.00)	1.40	2.25
20	26.8	Shunt	Left	(35.00)	1.50	.20
21a	25.0	Shunt	Back	(49.00)	1.60	1.50
21b	25.0	Shunt	Left	(49.00)	2.38	.30
22	25.0	Shunt	Front	85.00	1.76	.63
23	25.5	Rectifier	Left	(65.50)	1.84	1.00
24a	30.0	Picture	Top	5.08	1.92	1.25
24b	30.0	Shunt and picture	Back	5.08	94.50	> 12.50
24c	30.0	Shunt and picture	Back	5.08	181.00	> 12.50
25	27.0	Shunt	Back	(133.00)	2.03	1.40
26	27.0	Shunt	Back	(22.30)	2.06	1.50
27	34.0	Picture	Front	(5.25)	2.54	5.00
28	25.0	Shunt	Left	(64.00)	2.50	1.10
29	33.5	Shunt	Back	5.97	3.10	2.50
30	25.1	Shunt	Left	(12.50)	3.50	1.10
31a	26.5	Shunt and picture	Back	(13.50)	3.63	.88
31b	26.5	Shunt and picture	Left	(13.50)	4.23	1.12
32	24.0	Shunt	Back	51.60	4.09	1.62
33	24.2	Shunt	Back	(17.00)	4.60	.75
34	26.5	Shunt	Back	22.50	5.80	1.00
35	26.0	Shunt	Back	8.10	6.30	1.10
36	26.2	Shunt	Back	5.50	7.61	2.50
37	25.5	Shunt	Left	(4.00)	7.61	2.60
38	26.0	Shunt	Bottom	24.00	9.81	.81
39	25.5	Shunt	Left	(8.50)	10.60	3.75
40	24.1	Shunt	Back	(27.60)	11.40	1.10
41	31.0	Shunt and picture	Left	(21.00)	24.40	11.20
42	27.0	Shunt	Left	(6.33)	29.50	3.75
43	28.5	Shunt	Left	11.00	47.40	10.00
44	23.5	Shunt	Back	13.90	51.00	1.25
45	26.2	Shunt	Bottom	9.58	89.20	8.80
46	23.0	Shunt	Left	0.19	97.10	.55
47	28.6	Shunt	Bottom	(1.85)	100.00	12.50
48	26.0	Shunt	Bottom	(0.88)	369.00	> 12.50
49a	29.0	Picture	Left	Not recorded	——	.40
49b	29.0	Picture	Top	Not recorded	——	.70
50a	31.0	Shunt and picture	Back	Not recorded	——	1.25
50b	31.0	Shunt and picture	Left	Not recorded	——	1.50
51a	27.0	Picture	Back	Insufficient	——	.50
51b	27.0	Picture	Top	Insufficient	——	.51
51c	27.0	Picture	Right	Insufficient	——	.53
51d	27.0	Picture	Left	Insufficient	——	.53
52	24.5	Improperly located film		Insufficient	——	.63
53	27.0	Rectifier	Left	Not recorded	——	.57
54	——	Picture	Front	Insufficient	——	1.10
55	27.5	Shunt	Left	Insufficient	——	4.20

[a] Subscripts indicate where more than one film was used.

[b] For film, the x-ray measurements are based upon the optical density at the point (4 mm diameter) of highest film density. For the survey instrument, the x-ray measurements are the average x-ray intensity over a rectangle approximately 7.0 cm by 1.8 cm. If all other factors are equal, this might account for differences between film and instrument measurement results.

[c] Picture refers to picture tube.

[d] Exposure time estimated from record kept by set owner or by surveyor are shown in parentheses. Generally an in-line timer was used to record film exposure time.

Table 5. Number of color TV receivers by x-radiation exposure rate and operating high voltage

X-radiation exposure rate (mR/hr)	Operating high voltage (kV)																	
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total
<0.040	47	14	18	27	46	73	90	121	83	39	16	6	1	1	0			582
0.040—<0.075	0	0	1	0	2	4	6	6	10	6	5	0	0	0	0			40
0.075—<0.125	0	0	0	1	2	1	3	3	5	10	5	0	1	1	0			32
0.125—<0.25	0	0	0	2	7	7	7	7	8	7	5	5	0	0	0			55
0.25 —<0.50	0	0	0	2	3	0	3	7	3	6	6	4	2	0	0			36
0.50 —<1.00	0	0	0	1	0	3	4	4	3	4	4	1	0	1	1			26
1.00 —<2.00	0	0	0	0	0	1	3	5	4	2	0	2	1	3	0			21
2.00 —<3.75	0	0	0	0	0	0	0	2	1	0	0	0	1	0	0	1		5
3.75 —<7.50	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	4
7.50 —<12.50	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	1	5
≥12.50	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2
Total	47	14	19	33	60	89	116	156	119	76	42	18	8	7	1	1	2	* 808
Percent exceeding 0.5 mR/hr	0	0	0	3.0	0	4.5	6.0	7.7	8.4	10.5	11.9	16.7	50.0	71.4	100.0	100.0	100.0	

* Operating high voltage measurements were not made on 316 receivers. Three of these receivers had radiation emissions above 0.5 mR/hr.

Table 6. Highest x-radiation exposure rate for color TV receivers distributed by year of purchase

X-radiation exposure rate (mR/hr)	Not recorded	1955–1962	1963	1964	1965	1966	1967	1968	Total
<0.040	31	34	16	45	103	240	385	2	856
0.040—<0.075		2		3	7	22	18		52
0.075—<0.125			2		7	14	15		38
0.125—<0.25	2	2	2	2	15	20	25		68
0.25—<0.50			1	2	14	14	13		44
0.50—<1.00	2		1	2	2	11	8		26
1.00—<2.00				3	7	7	6		23
2.00—<3.75						3	2		5
3.75—<7.50					1	1	3		5
7.50—<12.50					1	4			5
≥12.50				1		1			2
Total	35	38	22	58	157	337	475	2	1,124

sure that the x-radiation level was below 0.5 mR/hr.

The servicing adjustments included 29 tube replacements for 27 of the 66 sets at or above 0.5 mR/hr. Two rectifier tubes type 3A3A were replaced. Twenty-seven shunt regulator tubes of type 6BK4, 6BK4A, or 6BK4B were replaced. For 36 of the 66 sets above 0.5 mR/hr, high-voltage adjustments alone reduced radiation to 0.5 mR/hr or lower as measured by the survey instrument. Three receivers did not have a service adjustment recorded on the survey data collection form.

The Washington area survey provided some data on viewing habits (table 7) of 2,311 individuals in 741 households: 743 household members viewed television from less than 8 feet. Three hundred and eighty persons stated they viewed color sets in excess of 30 hours per week. Approximately 20 percent of the individuals under 15 years of age view color television more than 30 hours per week. Information given by the person interviewed in the home indicated 328 of 547 viewers under age 15 view television at less than 8 feet and 48 at distances under 4 feet.

Conclusions

1. Some x-radiation emission was observed in a variety of makes and models of the 1,124 receivers surveyed in the Washington metropolitan area.

2. One of the most important findings of the survey was that 856 of the 1,124 receivers surveyed emitted no measurable levels of x radiation. The survey results demonstrate that the

Table 7. Household members by age, normal viewing distance and hours per week viewing time

	Number of persons at viewing distance						
	Total	Under 4 ft.	4 to 7 ft.	8 to 11 ft.	12 to 15 ft.	16+ ft.	Not indicated
All ages	2,311	84	659	969	484	71	44
Viewing hr/wk:							
15 and under	1,061	49	290	442	225	39	16
16–30	845	24	239	376	179	19	8
31+	380	11	127	148	78	13	3
Not indicated	25	0	3	3	2	0	17
Under 15 years old	547	48	280	150	39	6	24
Viewing hr/wk:							
15 and under	198	22	100	53	10	5	8
16–30	219	18	104	64	25	1	7
31+	120	8	74	33	4	0	1
Not indicated	10	0	2	0	0	0	8
15–44 years old	1,049	23	232	497	255	30	12
Viewing hr/wk:							
15 and under	536	16	123	242	134	14	7
16–30	360	5	78	189	79	8	1
31+	149	2	30	65	42	8	2
Not indicated	4	0	1	1	0	0	2
45 years old and over	715	13	147	322	190	35	8
Viewing hr/wk:							
15 and under	327	11	67	147	81	20	1
16–30	266	1	57	123	75	10	0
31+	111	1	23	50	32	5	0
Not indicated	11	0	0	2	2	0	7

industry has produced color television sets that can be operated well within the National Council on Radiation Protection and Measurements' recommendation and in most instances with x-radiation emission levels approaching normal background radiation in homes.

3. The primary sources of x-ray emissions are (1) the high-voltage shunt regulator tube, (2) the high-voltage rectifier tube, and (3) the picture tube.

4. The operating high voltage for television receivers demonstrably affects production and emission of x radiation from components.

5. It is possible to reduce x-radiation emissions both through service adjustments, including replacement of shunt regulator or high-voltage rectifier tubes, and reduction of the operating high voltage.

6. The survey technique did not provide data to support a valid association of observed x-radiation conditions with individual brand name or manufacturer on a nationwide basis.

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Technical Notes

Summary of Gonadal and Genetically Significant Dose from X Rays in the United States, 1964

Phyllis Segal and *Morton L. Brown*[1]

The 1964 X-ray Exposure Study conducted by the U.S. Public Health Service was undertaken to obtain information on the x-ray experience of the U.S. population during that year. The study was designed in five sequential stages:

1. a household interview survey of a representative sample of the U.S. population to obtain x-ray visit data;
2. a mail followup to the x-ray facilities where reported visits took place, to obtain technical data;
3. the merging and processing of the above sets of data to produce estimates of x-ray visits and examinations by the U.S. population;
4. the development of dosimetric models for estimating gonadal dose from the exposure data generated by the X-ray Exposure Study; and
5. the estimation of gonadal doses and the genetically significant dose for the U.S. population based on the dosimetric models and the exposure data.

Estimates of the number and distribution of x-ray visits and examinations, and estimates of exposure were published in an earlier report, "Population Exposure to X-rays, U.S. 1964" (*1*). A forthcoming publication, "Population Dose from X-rays, U.S. 1964," will present the dose models developed for the study as well as estimates of gonadal and genetic dose for the U.S. population. The following is a summary of selected data from the latter publication.

Table 1 shows the mean gonadal dose (in millirads) from radiographic procedures by body area, age, and sex. Mean gonadal doses from examinations over all body areas were significantly lower for children than for adults. Other data collected in this study suggest this is due in part to lower mean doses for abdominal examinations of children and in part from the relatively higher concentration of examinations of the skull and extremities in the pediatric age group.

Table 1. Mean gonadal doses (in millirads) from radiographic procedures by body area, age, and sex United States, 1964

Body area	All ages [a]	Under 15	15–29	30–44	45 and over [a]
Male:					
All body areas	239	35	262	340	255
Head and neck	3	<1	(b)	(b)	17
Thorax	8	2	24	2	4
Abdomen	1,071	222	1,808	1,340	837
Extremities	57	9	79	11	159
Female:					
All body areas	70	16	77	106	101
Head and neck	3	(b)	(b)	9	(b)
Thorax	7	12	4	10	6
Abdomen	351	138	370	352	422
Extremities	<1	1	<1	<1	(b)

[a] Category includes females under 50 years of age and males under 65.
[b] Figure does not meet standards of reliability or precision due to small sample size.

Testicular doses resulting from examinations of the abdomen reflected the impact of beam sizes larger than the minimum size needed to expose the film. The size of the useful beam is an important determinant of the amount of x-ray exposure received by the patient during examinations. Although strict collimation of the x-ray beam to the size of the film is an effective control of excess radiation, the data in figure 1 show that beam size was frequently in excess of film size, thus producing the relatively large gonadal doses shown for examinations of the abdomen of males.

Due to the design of the study, it was possible to simulate estimates of gonadal dose which would result if beam sizes had been restricted to effective beam sizes (i.e., to the size of the receptor film) (*2*). These estimates showed

[1] Mrs. Segal is public health analyst and Mr. Brown is deputy chief, Population Exposure Studies, Population Studies Program, National Center for Radiological Health, Rockville, Md. 20852.

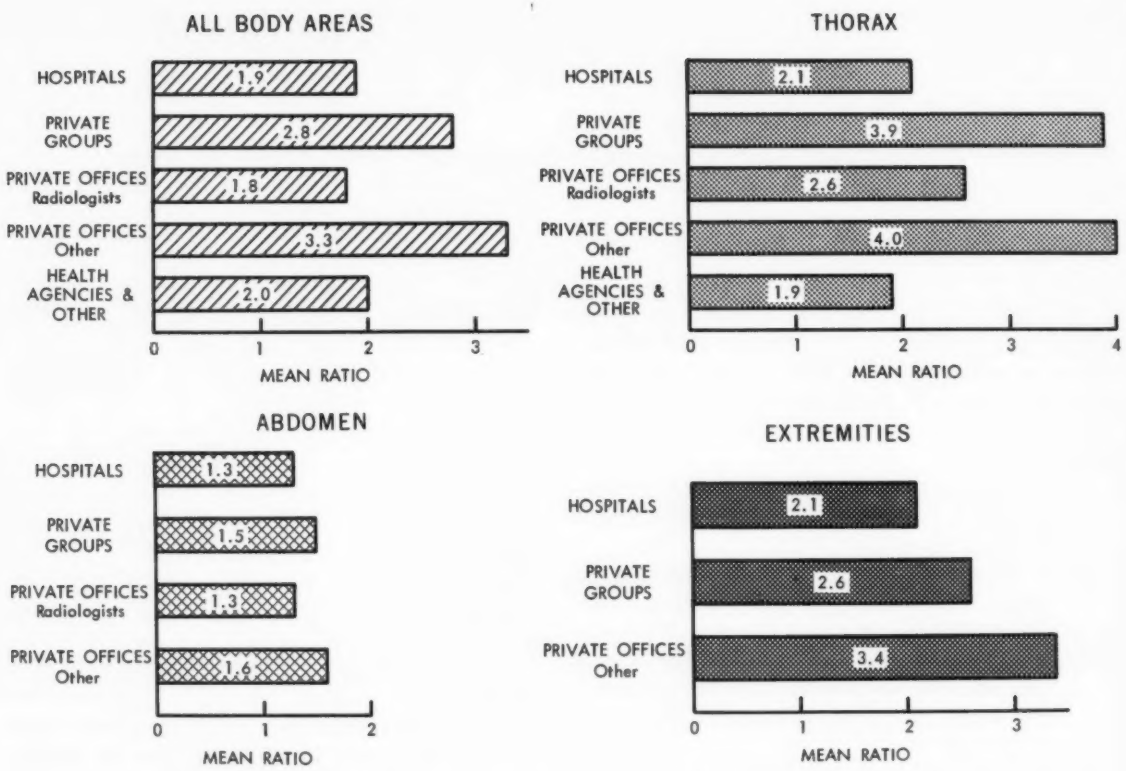

Figure 1. Estimated mean ratio of beam area to film area for radiographic films for selected body areas by type of facility, United States, 1964

a marked reduction of testicular doses. Comparable estimates of ovarian doses reflected more modest reductions due to the fact that the ovaries are located close to areas of diagnostic interest, and hence may not be excludable from the useful beam for certain examinations.

As was reported in "Population Exposure to X-rays, U.S. 1964," abdominal examinations performed in hospitals, private group practices, and by radiologists in private offices involved approximately one-half the mean exposure per film compared to those performed in the private offices of other practitioners. Table 2 presents estimates of mean gonadal doses per film by sex, body area and type of facility for radiographic examinations. While doses for thoracic films varied little among the types of facilities, the data suggest that those done in private offices of radiologists may be somewhat lower in mean gonadal dose than those done elsewhere. Ovarian doses from abdominal films varied little by type of facility. However, for males, the data indicate that testicular dose levels are higher in private offices of nonradiologists than in other facilities. Mean gonadal doses for films of the head and neck and of the extremities are also presented, although the sample size for these groups precludes comparison by facility type.

Estimated mean gonadal doses for selected types of roentgenologic examinations are shown in table 3. Gonadal doses from radiographic examinations ranged from less than 1 millirad to over 2 rads. Examinations of the abdomen and pelvis were found to yield the highest mean gonadal doses, while examinations of the head and neck and extremities yielded low gonadal doses, as might be expected.

It may be seen that mean gonadal doses for fluoroscopic examinations are low, by comparison with the comparable doses for radiographic films taken in conjunction with fluoro-

Table 2. Mean gonadal dose (in millirads) per film by sex, body area and type of facility for all radiographic examinations, United States, 1964

Sex and body area	All facilities	Hospital	Private office radiologists	Private office and other private group	Mobile unit health agencies and others
Males:					
Head and neck [a]	<1	1	<1	<1	0
Thorax [b]	6	8	4	6	<1
Abdomen [c]	273	258	281	343	7
Extremities [d]	23	35	<1	2	<1
Females:					
Head and neck [a]	1	1	<1	<1	<1
Thorax [b]	5	4	1	3	8
Abdomen [c]	100	103	71	98	0
Extremities [d]	<1	<1	<1	<1	<1

[a] Skull, cervical spine.
[b] Photofluorographic, radiographic, shoulder, thoracic spine.
[c] Cholecystography or cholangiogram, lumbar spine, upper gastrointestinal, barium enema, abdomen, KUB, flat plate, intravenous or retrograde pyelogram, pelvis or lumbo-pelvic area, hip.
[d] Upper extremities, lower extremities.

Table 3. Mean gonadal dose per examination (in millirads) by selected type of examination, United States, 1964

Type of examination	Total	Testicular	Ovarian	Fetal
Skull	2	<1	4	7
Cervical spine	5	8	2	3
Chest:				
Radiographic	6	5	8	6
Photofluorographic	4	<1	8	8
Fluoroscopic	28	1	71	(*)
Thoracic spine	139	184	9	9
Shoulder	<1	<1	<1	<1
Upper gastrointestinal series:				
Radiographic	222	130	360	343
Fluoroscopic	85	7	198	198
Barium enema:				
Radiographic	1,042	1,535	439	417
Fluoroscopic	203	50	366	397
Cholecystography or cholangiogram	88	2	193	206
Intravenous or retrograde pyelogram	1,436	2,091	407	451
Abdomen, KUB, flat plate	263	354	289	291
Lumbar spine-lumbo-sacral	1,759	2,547	420	239
Pelvis or lumbo-pelvic	604	717	41	82
Hip	917	1,064	309	366
Upper extremities	1	2	<1	(*)
Lower extremities	69	96	<1	<1
All other:				
Radiographic	69	52	92	251
Fluoroscopic	229	229	0	0

[*] Figure does not meet standards of reliability or precision due to small sample size.

scopic examinations of the gastrointestinal tract. The differential is particularly marked for testicular doses. This finding suggests that one of the major factors responsible for the low estimated fluoroscopic dose is the complete exclusion of the testes from the direct beam and partial exclusion of the ovaries, due to the small field sizes used in fluoroscopy.

In the past, fluoroscopy was known to produce high dose levels to the patient, but the data from the 1964 x-ray exposure study indicate that this may no longer be the case. This suggests that improvements in the design of fluoroscopic equipment, and the less frequent use of fluoroscopy by non-radiologists have resulted in lower dose levels from fluoroscopic examinations. The close collimation used in fluoroscopy with resulting low gonadal doses is further indication that fluoroscopy is no longer as significant a source of overexposure as in the past.

Photofluorography results in low gonadal doses since it should not involve direct beam irradiation of the gonads.

The *genetically significant dose* to a population is defined as the gonadal dose which, if received by every member of the population, would result in the same total genetic effect to

the population as the doses which are, in fact, received by individuals within the population (*3*). The following formula was used in order to determine the genetically significant dose to the U.S. population in 1964:

$$GSD = \frac{\sum_i D_i \hat{N}_i P_i}{\sum_i N_i P_i}$$

where,

D_i = the mean gonadal dose for a specified type of examination for a patient in age-sex class (i),

$\hat{N}_i$ = the number of persons in age-sex class (i) who had the specified type of examination during a year,

P_i = the expected number of future children to an individual in age-sex class (i), and

N_i = the number of persons in age-sex class (i) in the total population.

Based on the data for the U.S. population for 1964, the genetically significant dose was estimated to be 55 millirads per person, per year.

This value is compared with estimates from other studies in table 4. One obvious difference contributing to the level of genetically significant dose is the examination rate found in each study. Table 4, therefore, also shows the genetically significant dose per examination for each study, obtained by dividing the total genetically significant dose by the annual number of examinations per capita. This rate represents normalization of genetically significant dose for examination rates, while retaining the effects of dose levels and population parameters upon the genetically significant dose. Using this index, the estimate for the United States is found to be similar to values for several other countries in which examination rates are lower than those for the United States.

Other factors which should be considered in analyzing international comparisons are the level of fecundity in each country, the differences in time period covered by each study, the differences in medical practices and the differences in methodology used in the various studies, particularly with regard to dosimetry.

Approximately 96 percent of the genetically significant dose to the U.S. population resulted from radiography, 4 percent from fluoroscopy, and less than 1 percent from photofluorography.

Figure 2 shows the percent contribution to genetically significant dose by sex and age class. It may be seen that the largest single contributing group was males aged 15 to 29.

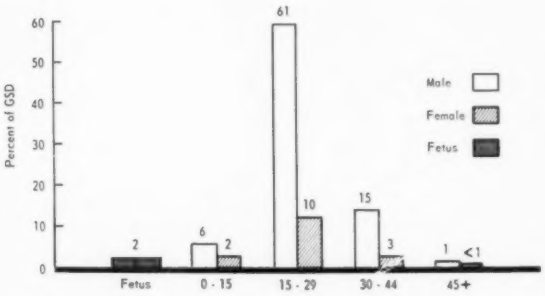

Figure 2. Estimated percent distribution of genetically significant dose from diagnostic medical roentgenology by age and sex, United States, 1964

Table 4. Comparison of annual genetically significant dose from diagnostic radiology

Locale	Investigator and date of study	GSD [c]	Estimated annual per capita examination rate	GSD per examination
United States	Gitlin, *et al.* (1964)	55	0.53	103
	Laughlin & Pullman (1955–1956)	[d] 50	.27	186
	Brown, *et al.* (1956–1957)	40	1.11	36
	Cooley & Beentijes (1960–1962)	18	.05	36
Richland, Wash.	Norwood, *et al.* (1953–1956)	45	.58	78
New York City	Heller (1962)	45	.73	62
France	Not available	58	.15	387
Sweden	Larsson (1955)	38	.29	130
Japan	Miyakawa, *et al.* (1960)	39	.41	95
Denmark	Hammer-Jacobsen (1956)	22	.24	92
Rome	Not available	43	.50	87
Great Britain	Adrian Committee (1957–1958)	14	.28	50
Leiden (Netherlands)	Nooteboom-Beekman (1959)	7	.35	20

[a] Adopted from a report by Pasternack & Heller (4) except for the 1964 United States value by Gitlin, *et al.* (1)
[b] Excluding examinations in TB centers, (including photofluorographic) and dental.
[c] Genetically Significant Dose.
[d] Their low range estimate.

The contribution to genetic dose by examination type is not proportional to the frequency of these examinations. A high percentage of the genetically significant dose is contributed by relatively few procedures. Although examinations of the thorax accounted for over 50 percent of the examinations reported in the X-ray Exposure Study, these examinations contributed only 4 percent to the genetic dose. Abdominal and pelvic examinations amounted to 25 percent of those reported in the study, yet the genetic dose from these examinations accounts for 90 percent of the total (figures 3 and 4).

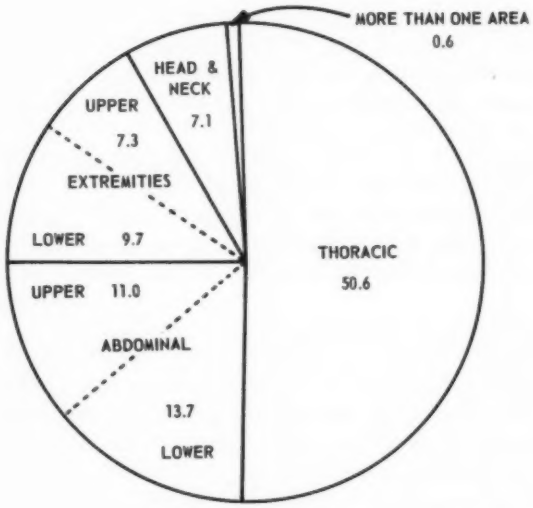

Figure 3. Estimated percent distribution of radiographic examinations by body area, United States, 1964

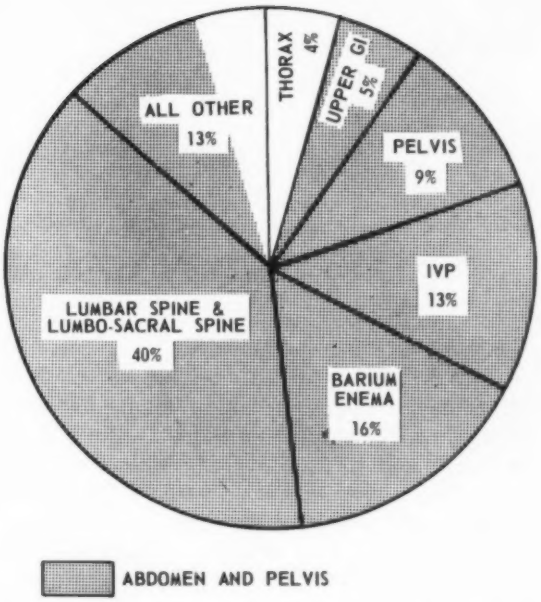

Figure 4. Estimated percent distribution of genetically significant dose by type of medical roentgenologic examination, United States, 1964

As described above, hypothetical gonadal doses calculated under the assumption that all examinations in the study had been conducted with beam sizes no larger than the film size resulted in a marked reduction of testicular doses. If this schedule of gonadal doses is used to calculate an estimated genetically significant dose, a reduction from 55 to 19 millirads per person per year, is observed. This reduction reflects only the impact of improved collimation, with no other changes in radiographic technique or in examination rates. This two-thirds reduction in genetic dose confirms the thesis that adequate collimation is the single most important factor in reducing excess population dose from diagnostic medical examinations.

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(3) Report of The United Nations Scientific Committee on the Effects of Atomic Radiation; General Assembly Official Records: Thirteenth Session, Suppl 17(A/3838), New York (1958).

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Data

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5, 6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk.

In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January–December 1967	August 1968

1. Pasteurized Milk Network
June 1968

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D.C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

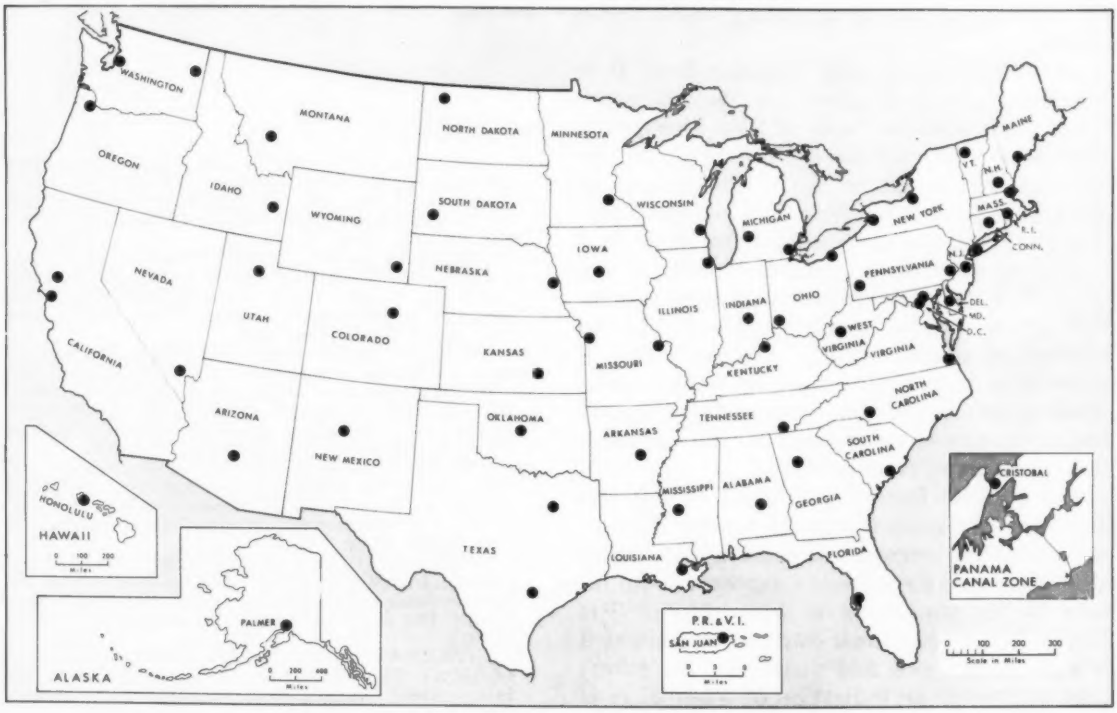

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for June 1968 and the 12-month period, July 1967 through June 1968[a]

Sample location		Radionuclide concentrations (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		July 1967–June 1968	June 1968	July 1967–June 1968	June 1968	July 1967–June 1968	June 1968	July 1967–June 1968	June 1968	July 1967–June 1968	June 1968
Ala:	Montgomery	0	0	9	9	0	0	14	19	0	0
Alaska:	Palmer	NA	NA	5	0	0	0	15	11	1	0
Ariz:	Phoenix	0	0	1	0	0	0	2	1	0	0
Ark:	Little Rock	1	0	21	27	0	0	19	24	0	0
Calif:	Sacramento	0	0	3	2	0	0	6	8	1	0
	San Francisco	1	0	2	0	0	0	4	4	1	0
C.Z:	Cristobal	0	0	2	0	0	0	10	6	0	0
Colo:	Denver	1	0	4	3	0	0	6	1	0	0
Conn:	Hartford	NA	NA	9	11	0	0	13	10	0	0
Del:	Wilmington	NA	NA	11	16	0	0	9	17	0	0
D.C:	Washington	0	0	10	12	0	0	6	17	0	0
Fla:	Tampa	0	0	8	9	0	0	68	65	0	0
Ga:	Atlanta	0	0	14	14	0	0	21	21	0	0
Hawaii:	Honolulu	0	0	3	5	1	0	5	6	0	0
Idaho:	Idaho Falls	1	0	6	8	0	0	8	8	0	0
Ill:	Chicago	0	0	9	9	0	0	10	8	0	0
Ind:	Indianapolis	NA	NA	7	9	0	0	7	3	0	0
Iowa:	Des Moines	0	0	7	10	0	0	7	8	0	0
Kans:	Wichita	1	0	9	10	0	0	5	9	0	0
Ky:	Louisville	0	0	12	14	0	0	6	16	0	0
La:	New Orleans	0	0	22	22	0	0	24	25	0	0
Maine:	Portland	NA	NA	10	14	0	0	30	31	0	0
Md:	Baltimore	0	0	10	14	0	0	5	18	0	0
Mass:	Boston	0	0	12	18	0	0	25	38	0	0
Mich:	Detroit	NA	NA	8	10	0	0	12	16	0	0
	Grand Rapids	NA	NA	10	16	0	0	14	19	0	0
Minn:	Minneapolis	1	7	11	11	0	0	12	21	0	0
Miss:	Jackson	0	0	17	20	0	0	14	19	0	0
Mo:	Kansas City	1	0	8	10	0	0	4	3	1	0
	St. Louis	0	0	9	9	0	0	7	8	0	0
Mont:	Helena	1	0	5	0	0	0	7	4	1	0
Nebr:	Omaha	1	0	8	10	0	0	5	4	0	0
Nev:	Las Vegas	0	0	2	0	0	0	4	6	0	0
N.H:	Manchester	NA	NA	13	19	0	0	34	47	0	0
N.J:	Trenton	NA	NA	10	15	0	0	10	17	0	0
N. Mex:	Albuquerque	0	0	2	4	0	0	3	6	0	0
N. Y:	Buffalo	NA	NA	8	12	0	0	11	10	0	0
	New York City	NA	NA	11	19	0	0	13	22	0	0
	Syracuse[b]	NA	NA	7	12	0	0	9	17	0	0
N. C:	Charlotte	0	0	16	18	1	0	12	12	0	0
N. Dak:	Minot	2	7	11	13	0	0	12	20	0	0
Ohio:	Cincinnati	NA	NA	9	12	0	0	7	16	0	0
	Cleveland	NA	NA	9	13	0	0	9	15	0	0
Okla:	Oklahoma City	0	0	10	15	0	0	4	11	0	0
Ore:	Portland	1	0	7	10	0	0	15	20	1	3
Pa:	Philadelphia	NA	NA	9	16	0	0	8	19	0	0
	Pittsburgh	NA	NA	12	19	0	0	14	19	0	0
P. R:	San Juan	0	0	5	6	0	0	11	14	0	0
R. I:	Providence	NA	NA	11	15	0	0	19	25	0	0
S. C:	Charleston	0	0	15	18	0	0	28	27	0	0
S. Dak:	Rapid City	1	0	10	14	0	0	10	20	0	0
Tenn:	Chattanooga	0	0	14	16	0	0	13	17	0	0
	Memphis	0	0	12	16	0	0	5	8	0	0
Tex:	Austin	0	0	4	4	0	0	3	1	0	0
	Dallas	0	0	7	15	0	0	6	16	0	0
Utah:	Salt Lake City	1	0	5	5	0	0	12	10	0	0
Va:	Norfolk	0	0	11	11	0	0	10	12	0	0
Vt:	Burlington	NA	NA	11	17	0	0	11	16	0	0
Wash:	Seattle	1	0	9	10	0	0	24	26	1	0
	Spokane	1	0	7	6	0	0	13	9	0	0
W. Va:	Charleston	0	0	12	28	0	0	4	17	0	0
Wisc:	Milwaukee	NA	NA	8	8	0	0	11	15	0	0
Wyo:	Laramie	0	0	4	6	0	0	6	0	0	0
Network monthly average		0	0	9	11	0	0	12	15	0	0

[a] See text for averaging procedure.
[b] 12-month average represents only 9-months data.
NA, no analysis.

analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*). Reference should also be made to the February 1968 issue (*2*), in which several changes in the interpretation and reporting of data were introduced.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages for June 1968 and 12-month averages for the period July 1967 through June 1968. The 12-month averages facilitate evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (*3*). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (*2*). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; iodine–131, cesium–137, and barium–140, 10.

The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

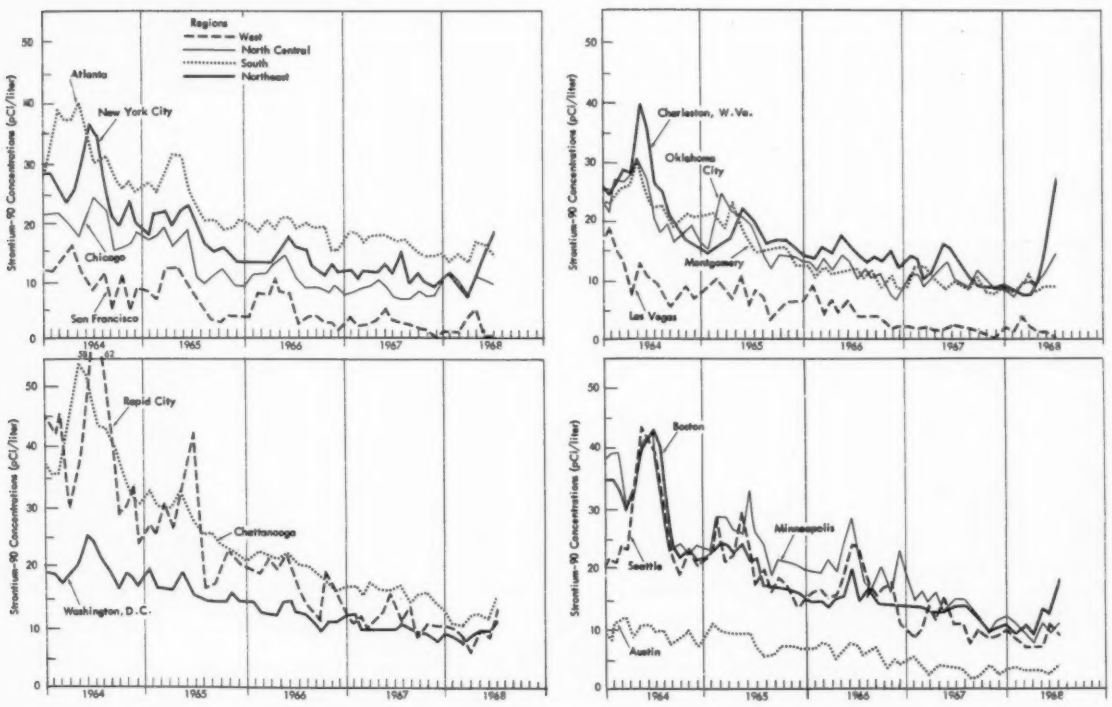

Figure 2. Strontium–90 concentrations in pasteurized milk, 1964–June 1968

2. Canadian Milk Network[1] June 1968

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (4).

The June 1968 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from July 1968 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable elements and radionuclides in Canadian whole milk, June 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.06	1.3	10	23
Edmonton	1.09	1.5	8	23
Ft. William	1.11	1.5	17	32
Fredericton	1.06	1.4	17	23
Halifax	1.11	1.4	12	27
Montreal	1.09	1.5	10	19
Ottawa	1.15	1.6	9	18
Quebec	1.09	1.4	16	29
Regina	1.09	1.4	7	18
St. John's, Nfld.	1.11	1.4	21	44
Saskatoon	1.11	1.4	8	17
Sault Ste. Marie	1.11	1.6	18	40
Toronto	1.15	1.6	6	17
Vancouver	1.15	1.5	17	56
Windsor	1.15	1.5	6	14
Winnipeg	1.15	1.4	7	18
Average	1.11	1.5	12	26

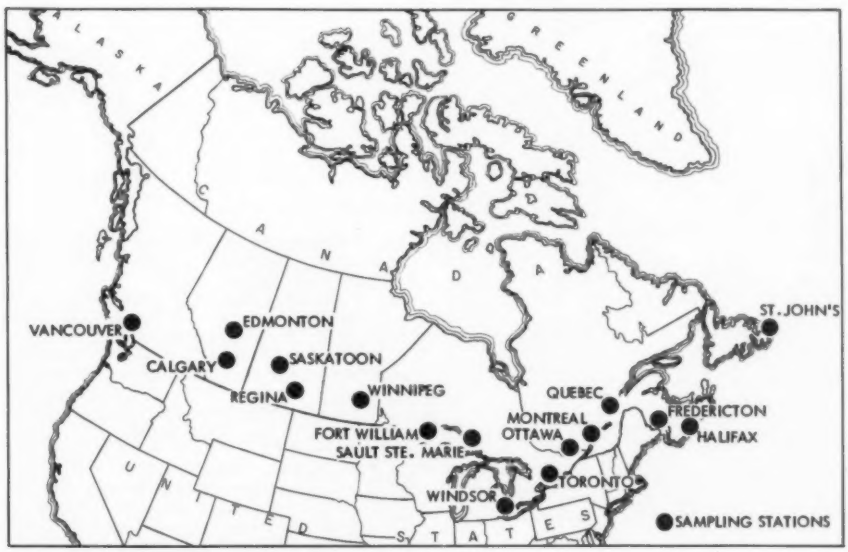

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program June 1968

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO-member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*5*).

Figure 4. Pan American Milk Sampling Program stations

Table 4 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for June 1968.

Table 4. Stable element and radionuclide concentrations in Pan American milk [a], June 1968

Sampling station	Number of samples	Potassium g/liter	Strontium-90 [b] (pCi/liter)	Cesium-137 [b] (pCi/liter)
Chile: Santiago	1	1.5	0	0
Colombia: Bogota	1	1.5	0	0
Ecuador: Guayaquil	1	1.6	0	0
Jamaica: Montego Bay	1	1.4	8	170
Venesuela: Caracas	1	1.5	0	0
Canal Zone: Cristobal [c]	4	1.5	0	6
Puerto Rico: San Juan	4	1.6	6	14

[a] All strontium-89 results were ≤5 pCi/liter; iodine-131 and barium-140 results were all ≤10 pCi/liter.
[b] Strontium-90 single sample results ≤2 pCi/liter and cesium-137 single sample results ≤10 pCi/liter are reported as 0.
[c] For comparison, the average radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 9:20–23 (January 1968).

(*2*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, October 1967. Radiol Health Data Rep 9:86–89 (February 1968).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*4*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*5*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and the last issue in which they appeared.

State milk network	Period reported	Last presented
California	January–March 1968	September 1968
Connecticut	January–March 1968	August 1968
Indiana	January–March 1968	August 1968
Iowa	January–March 1968	August 1968
Michigan	January–March 1968	August 1968
Minnesota	January–March 1968	August 1968
New York	January–March 1968	August 1968
Oklahoma	September–December 1967	April 1968
Oregon	January–March 1968	September 1968
Pennsylvania	January–March 1968	August 1968
Washington	January–March 1968	September 1968

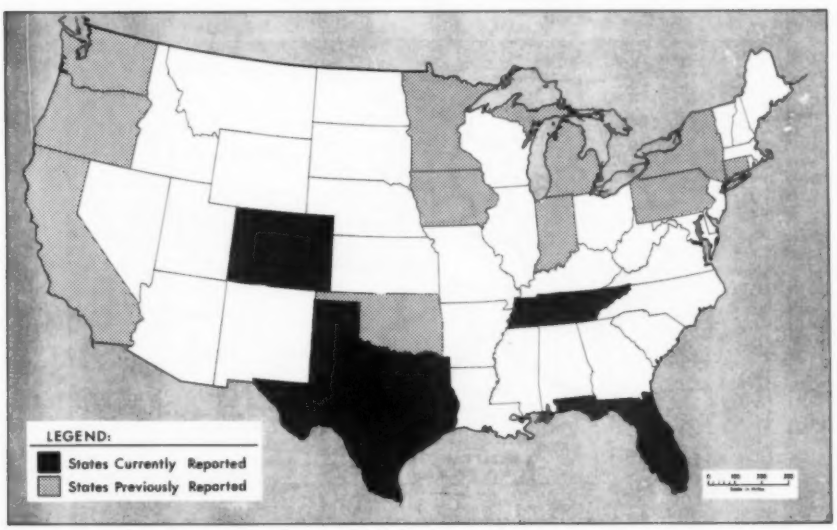

Figure 1. Reported State milk programs

1. Colorado Milk Network April–June 1968

Air, Occupational and Radiation Hygiene Division
Colorado State Department of Public Health

The Radiation Hygiene Section of the Colorado State Health Department initiated analysis of milk for gamma-ray emitting radionuclides in January, 1962. Initially a composite milk sample from the major producers supplying the Denver area was collected by the Denver City and County Health Department for the State.

In August 1962, the State expanded this program to include the sampling of raw milk from the major milk producing areas supplying the entire State. The routine sampling rate depends on the activities of the Milk, Food and Drug Section of the State Health Department. Milkshed areas are shown in figure 2.

Analyses are performed for iodine–131, cesium–137, barium-lanthanum–140 and potassium by gamma-ray spectrometry. Employed in this procedure is a 4- by 5-inch diameter NaI (Tl) crystal housed in a modified office safe lined with 2 inches of lead and a 512 multichannel pulse-height analyzer using a typewriter readout. Samples and backgrounds are counted for 40 minutes in a 2 quart (1,892 ml) plexiglass Marinelli beaker. Calculation is by the matrix method (*1*) and the minimum detectable concentrations are: iodine–131, 15 pCi/liter; cesium–137, 16 pCi/liter; barium-lanthanum–140, 16 pCi/liter; and potassium, 0.25 g/liter.

Eleven milk samples were collected and counted during the period from April 1 to June 30, 1968. Iodine–131, cesium–137 and barium-lanthanum–140 were below the respective minimum detectable concentrations in all but three samples from area 4 (figure 2). These concentrations were 30 pCi/liter in two samples for iodine–131. The third sample concentrations for iodine–131 and barium-lanthanum–140 were each 16 pCi/liter. Potassium concentrations averaged 1.4 ± 0.2 (2σ) g/liter.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967	April 1968
January–March 1968	July 1968

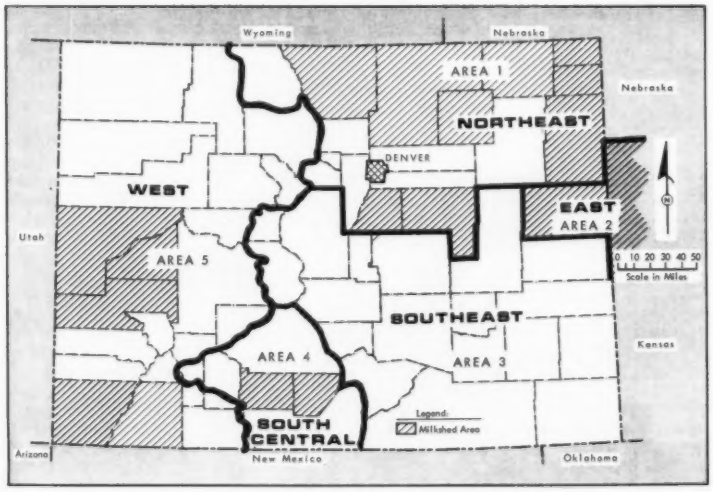

Figure 2. Colorado milk sampling stations

2. Florida Milk Network April–June 1968

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–90, cesium–137, barium–140 and potassium, in addition to iodine–131. Analysis for strontium–89 was made until 1965 but due to extremely low levels has been discontinued since that time. Monthly sample collection procedures for obtaining milk from randomly selected farms in each of the six regions of the State was redesigned in July 1968 (figure 3). Beginning in July 1968, a 1-gallon raw milk sample is collected monthly from a major processing plant in each of the regions referenced above. The milk produced in each region is generally processed and consumed in that region. The processing plant from which the milk sample is obtained was selected on its percentage contribution to the total milk market.

The sample of milk is collected in each region on Monday or Tuesday following the first Sunday of each month. The maximum age of any portion of the milk making up the sample is 72 hours. The samples are sent to the State Board of Health Radiological Laboratory in Orlando for analyses. The samples are analyzed and corrected for decay to the time and date of collection.

Strontium–90 is determined by the ion exchange method developed by Porter et al. (*2*). Iodine–131, cesium–137, barium–140 and potassium are determined by gamma-ray spectrometry (*3*).

Radionuclide concentration levels for April through June 1968, are presented in table 1.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967	April 1968
January–March 1968	July 1968

Figure 3. Florida milk sampling areas

Table 1. Stable element and radionuclide concentrations in Florida raw milk, April-June 1968

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	April	May	June	April	May	June	April	May	June	April	May	June	April	May	June
West	1.3	1.6	1.4	14	17	17	ND	ND	25	ND	45	21	ND	27	<20
North	1.4	1.7	NS	14	15	NS	ND	ND	NS	ND	43	NS	ND	ND	NS
Northeast	1.5	1.7	1.5	6	NA	10	ND	28	<20	130	93	76	58	30	23
Central	NS	NS	1.6	NS	NA	13	NS	NS	<20	NS	NS	89	NS	NS	<20
Tampa Bay area	1.4	1.5	1.6	7	7	6	ND	ND	<20	55	99	77	ND	ND	<20
Southeast	1.4	1.6	1.5	9	8	8	ND	ND	<20	72	92	89	ND	23	<20

NA, no analysis.
ND, nondetectable.
NS, no sample.

3. Tennessee Milk Network April–June 1968

Division of Preventable Diseases
Department of Public Health,
State of Tennessee

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from four cities (figure 4). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample of milk is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city sampled are analyzed by gamma-ray scintillation spectrometry for potassium–40, iodine–131, cesium–137, and barium–140, using a 3½-liter sample (*4*). After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter radioactivity, after which strontium–89, strontium–90, and barium–140 concentrations are determined radiochemically using ion-exchange procedures (*5*). Chemical analyses are also made for stable calcium and potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a cross-check between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 2 for the period of April through June 1968.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967	April 1968
January–March 1968	July 1968

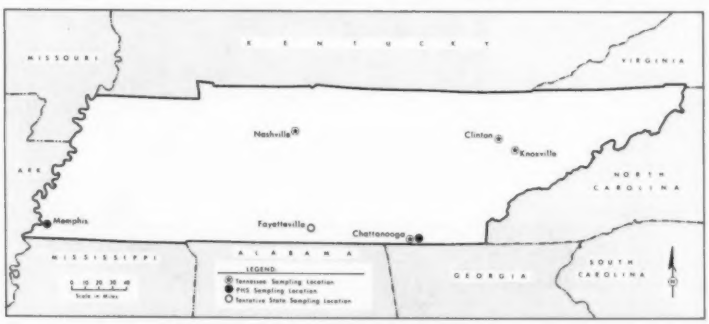

Figure 4. Tennessee pasteurized milk sampling stations

Table 2. Radionuclides in Tennessee pasteurized milk, April-June 1968

Location	Month 1968	Concentration (g/liter)	Radionuclide concentration (pCi/liter)				
		Potassium	Strontium 89	Strontium 90	Iodine-131	Cesium-137	Barium-140
Chattanooga	April	1.6	<5	14	<9	21	<8
	May	1.4	NA	NA	<9	20	<8
	June	1.5	10	12	<9	27	<8
Clinton	April	1.6	<5	20	<9	29	<8
	May	1.4	NA	NA	<9	21	<8
	June	1.6	11	14	<9	29	<8
Knoxville	April	1.5	<5	13	11	30	<8
	May	1.5	NA	NA	<9	23	<8
	June	1.4	5	10	<9	19	13
Nashville	April	NS	NS	NS	NS	NS	NS
	May	1.6	<5	NA	<9	22	<8
	June	1.5	<5	10	<9	14	<8

NA, no analysis.
NS, no sample.

4. Texas Milk Network April–June 1968

Texas State Department of Health[2]

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, samples of raw milk are collected from each of twelve sampling points once each calendar quarter. The station locations shown in figure 5 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–90 by a chemical separation technique employing ion exchange columns (*6*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

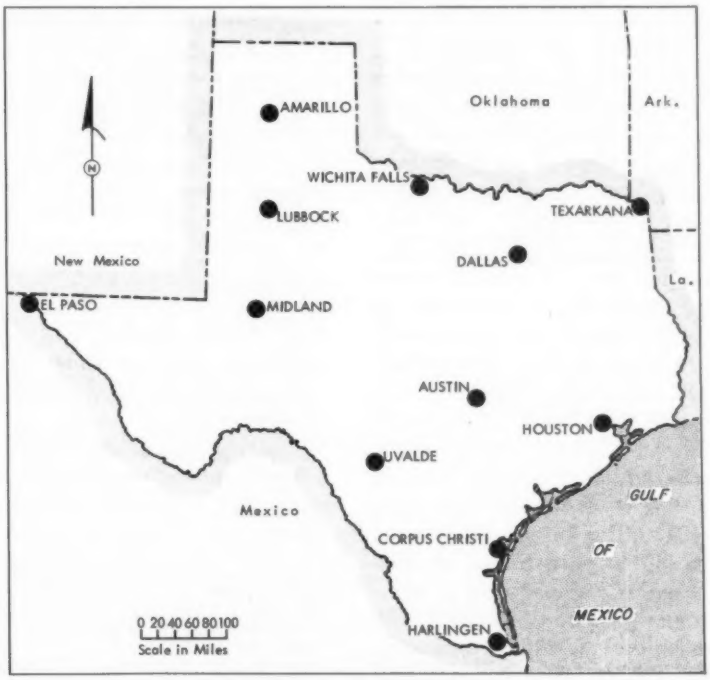

Figure 5. Texas milk sampling stations

Potassium–40, iodine–131, cesium–137 and barium–140 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5 liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium, strontium–90 and cesium–137 results by station and month for April through June 1968 are presented in table 3. During this time, the iodine–131 and barium–140 concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through June 1968 is presented in figure 6.

Table 3. Radionuclide concentrations in Texas raw milk network,[a] April-June 1968

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Apr	May	June	Apr	May	June	Apr	May	June
Amarillo	—	—	1.3	—	—	3	—	—	[b] <10
Corpus Christi	—	1.5	—	—	5	—	—	10	—
El Paso	—	1.4	—	—	3	—	—	<10	
Fort Worth	1.5	—	—	10	—	—	10	—	—
Harlingen	—	—	1.6	—	—	2	—	—	<10
Houston	—	1.5	—	—	13	—	—	20	—
Lubbock	NA								
Midland	1.6	—	—	4	—	—	<10	—	—
San Antonio	—	—	1.5	—	—	2	—	—	<10
Texarkana	—	—	1.5	—	—	12	—	—	15
Uvalde	1.5	—	—	3	—	—	<10	—	—
Wichita Falls	NA								

[a] Samples collected on a quarterly frequency at each sampling location.
[b] Below detectable limits.
NA, no analysis.

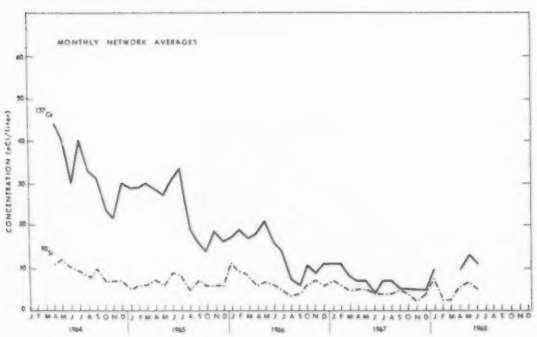
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1964
1965
1966
1967
1968

Figure 6. Radionuclide concentrations in Texas milk April 1964–June 1968

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*7*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967	April 1968
January–March 1968	July 1968

REFERENCES

(*1*) COLORADO STATE DEPARTMENT OF PUBLIC HEALTH, OCCUPATIONAL AND RADIOLOGICAL HEALTH DIVISION. Colorado milk network, October–December 1964 and summary 1962–1964. Radiol Health Data 6:202–204 (April 1965); January 1965–June 1966. Radiol Health Data Rep 7:573–575 (October 1966).

(*2*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium–90 in milk by ion-exchange method. Anal Chem 33:1306–1309 (September 1961).

(*3*) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL HEALTH. Florida milk network, July–December 1964. Radiol Health Data 6:611–612 (November 1965).

(*4*) PORTER, C., R. AUGUSTINE, J. MATUSEK, JR., and M. CARTER. Procedures for Determining Stable Nuclides in Environmental Samples, PHS No. 999–RH–10. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (January 1965).

(*5*) PORTER, C., M. CARTER, B. KAHN, and E. PEPPER. Rapid Field Method for the Collection of Radionuclides from Milk. Proceedings of the First International Congress of the International Radiation Protection Association held in Rome, Italy, September 5–10, 1966 (in press).

(*6*) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by ion exchange method. Anal Chem 36:676–678 (March 1964).

(*7*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Connecticut Standard Diet	July–December 1967	May 1968
Tri-City Diet, HASL	April–December 1967	June 1968

1. Radionuclides in Institutional Diet Samples January–March 1968

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and 8 auxiliary institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1, 2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

Sampling procedures

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass.

The sample for each day is packaged in three parts: (1) solid food and semisolid food minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking water is not included in these samples. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

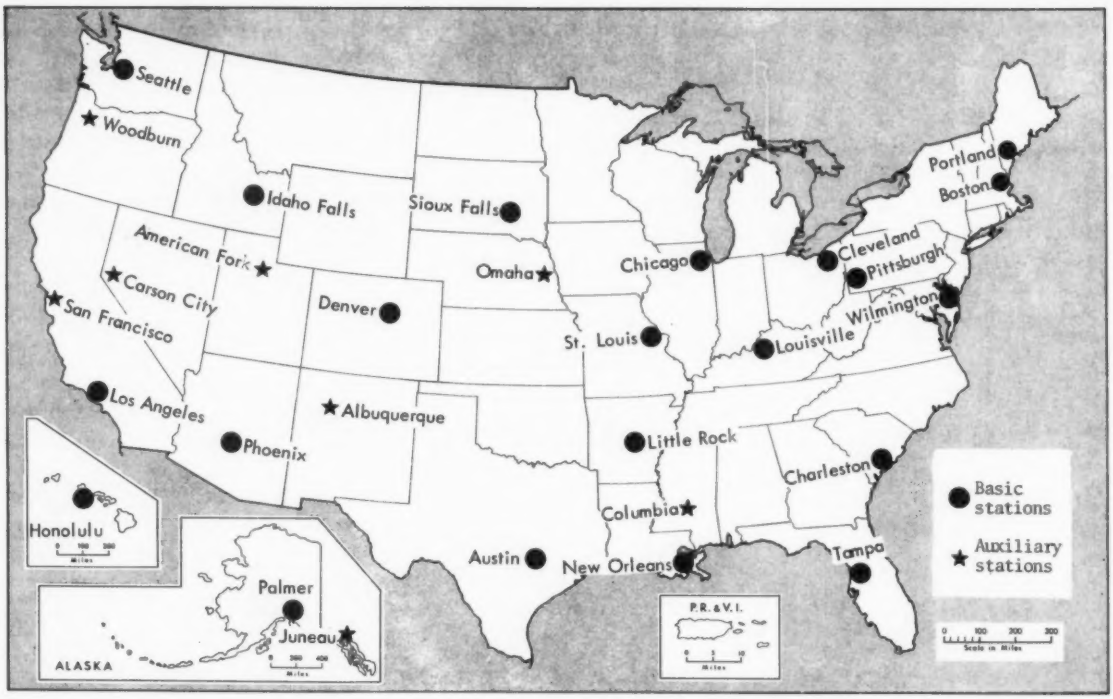

Figure 1. Institutional diet sampling locations as of March 1968

A water sample is collected once a year and analyzed from each institution. For each new institution a water sample is collected and analyzed each quarter for the first year and then once a year subsequently. If an institution is not in a milkshed of the Pasteurized Milk Network, a special milk sample is collected monthly.

Analytical procedures

When the samples arrive at the laboratory, an identification number is assigned to each weekly sample. Total weight is accurately determined. Sample volumes usually range from 6 to 16 liters; sample weights range from 8 to 20 kilograms. A commercial blender or specially constructed homogenizer is used to make the sample homogeneous so that aliquots will be identical in composition. Portions of the slurry are measured into appropriate containers for analysis by gamma spectrometry and/or for ashing prior to radiochemical analysis.

Stable calcium is measured because calcium compounds may influence the uptake of bone-seeking radionuclides such as radiostrontium. Stable potassium is measured as it provides a handy reference point for the analysis. An unusual concentration of potassium–40 and therefore of stable potassium indicates something is wrong with the analysis, with the sample, or with both.

Stable calcium is analyzed by the permanganate titration procedure after an aliquot of the sample is ashed. Stable potassium, iodine–131, barium–140 and cesium–137 are analyzed by gamma spectrometry. Strontium–89 and strontium–90 are analyzed by chemical separation or ion exchange techniques. Radium–226 is analyzed by the radon–222 emanation method. The details of these analyses can be found in the NCRH document entitled "Radioassay Procedures for Environmental Samples" (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1968, for children 9 to 12 years of age. The stable elements, calcium and

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age), January–March 1968

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	Jan	1.58	0.9	1.4	1.4	2.3	6	9	11	17	0.4	0.6
	Feb	1.63	.6	1.0	1.3	2.1	15	25	18	29	.4	.6
	Mar	2.11	.6	1.2	1.3	2.8	5	10	0	0	.5	1.1
Ariz: Phoenix	Jan	2.56	.6	1.6	1.2	3.0	5	13	12	31	.4	1.0
	Feb	2.18	.5	1.1	1.2	2.6	5	10	0	0	.3	.6
	Mar	1.45	.4	0.6	1.2	1.7	0	0	18	26	.3	.4
Ark: Little Rock	Jan	1.89	.6	1.2	1.8	3.4	12	23	16	30	.6	1.1
	Feb	1.67	.6	1.1	1.5	2.6	12	21	11	18	.7	1.2
	Mar	1.81	.6	1.1	1.6	2.9	7	13	0	0	.4	.7
Calif: Los Angeles	Jan [a]	1.61	.5	.8	1.3	2.2	5	9	14	23	.8	1.3
	Feb	1.57	.5	.8	1.4	2.2	5	8	0	0	.6	.9
	Mar [a]	1.95	.5	1.0	1.3	2.5	5	10	14	27	.6	1.2
Colo: Denver	Jan [a]	2.30	.8	1.7	1.2	2.8	6	13	11	25	.5	1.2
	Feb	2.05	.7	1.4	1.5	3.1	7	11	0	0	.5	1.0
	Mar	2.35	.8	1.9	1.6	3.8	4	10	18	42	.7	1.4
Del: Wilmington	Jan	2.01	.8	1.5	1.8	3.6	10	21	13	26	.4	.8
	Feb	2.14	.6	1.3	1.7	3.6	8	16	0	0	.4	.9
	Mar	2.11	.8	1.6	1.7	3.6	8	18	0	0	.9	1.9
Fla: Tampa	Jan	1.78	.4	.8	1.7	3.0	6	10	34	60	.7	1.2
	Feb	2.16	.6	1.2	1.8	4.0	10	21	31	67	.7	1.5
	Mar	2.20	.6	1.2	2.0	4.0	8	18	32	70	.4	.9
Hawaii: Honolulu	Jan	1.90	.5	.9	1.4	2.7	2	5	20	38	.4	.8
	Feb	2.19	.5	1.1	1.4	3.0	2	5	15	33	.4	.9
	Mar	2.48	.5	1.2	1.4	3.5	3	7	18	45	.4	1.0
Idaho: Idaho Falls	Jan [a]	2.30	1.3	2.9	1.8	4.1	13	30	12	27	.4	.9
	Feb [a]	2.25	1.0	2.3	1.7	3.8	7	16	0	0	.6	1.3
	Mar [a]	1.91	.9	1.7	1.4	2.6	10	18	18	34	.5	.9
Ill: Chicago	Jan	1.62	.7	1.2	1.6	2.6	6	10	18	29	.6	1.0
	Feb [a]	1.53	.7	1.1	1.5	2.3	7	10	15	23	.8	1.2
	Mar	1.57	.8	1.6	1.8	2.8	6	9	22	34	.6	.9
Ky: Louisville	Jan	1.35	.8	1.0	1.9	2.6	8	10	0	0	.5	.7
	Feb	1.73	.7	1.3	1.6	2.8	7	12	14	24	.4	.7
	Mar	1.39	.5	.8	1.5	2.1	7	10	0	0	.6	.8
La: New Orleans	Jan	1.86	.8	1.5	1.6	3.0	14	25	20	37	.5	.9
	Feb	2.14	.8	1.7	1.8	3.8	17	37	14	30	.5	1.1
	Mar	1.90	.7	1.3	1.8	3.4	12	23	14	27	.5	1.0
Mass: Boston	Jan	1.82	.7	1.3	1.5	2.8	8	15	17	31	.6	1.1
	Feb	1.51	.7	1.0	1.4	2.1	7	10	16	24	.5	.8
	Mar	1.68	.7	1.3	1.3	2.2	10	13	19	32	.4	.7
Mo: St. Louis	Jan	2.49	.9	2.3	1.7	4.3	9	23	0	0	.8	2.0
	Feb	2.63	1.1	3.0	1.8	4.6	9	24	25	66	1.0	2.6
	Mar	2.59	1.2	3.2	1.8	4.5	10	27	12	31	1.1	2.8
Ohio: Cleveland	Jan	1.42	.6	1.0	1.8	2.5	8	12	18	26	.7	1.0
	Feb	1.73	.6	1.1	1.7	3.0	9	15	24	42	.7	1.2
	Mar	1.15	.7	.8	1.8	2.0	10	11	18	21	.7	.8
Pa: Pittsburgh	Jan	2.22	.6	1.3	1.5	3.4	9	20	0	0	.8	1.8
	Feb	2.27	.5	1.2	1.4	3.1	9	19	23	52	.7	1.6
	Mar	2.19	.6	1.3	1.4	3.1	8	18	12	26	.6	1.3
S. C: Charleston	Jan [a]	2.10	.8	1.7	1.3	2.8	10	21	22	46	1.4	2.9
	Feb	1.45	.6	.8	1.6	2.4	7	11	16	23	.7	1.0
	Mar	1.39	.8	1.1	1.7	2.4	11	16	21	29	1.1	1.5
S. Dak: Sioux Falls	Jan	1.23	1.2	1.4	1.6	2.0	17	21	11	13	.7	.9
	Feb	1.21	.7	.8	1.4	1.7	5	6	0	0	.7	.8
	Mar	1.14	.8	.9	1.6	1.9	8	9	18	20	1.0	1.1
Tex: Austin	Jan	1.73	.5	.9	1.3	2.2	5	8	0	0	.5	.9
	Feb	1.79	.6	1.0	1.5	2.8	5	9	26	46	.6	1.1
	Mar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Maine: Portland	Jan	1.55	.9	1.3	1.7	2.6	15	24	25	39	.9	1.4
	Feb	1.48	.8	1.2	1.7	2.5	13	20	35	52	.8	1.1
	Mar	1.49	.9	1.4	1.6	2.3	13	20	16	24	.6	.9
Wash: Seattle	Jan [a]	1.71	.5	.8	1.7	2.9	4	7	16	27	.5	.9
	Feb [a]	2.20	.4	.9	1.3	2.9	4	9	0	0	.5	1.1
	Mar [a]	1.75	.5	.9	1.7	3.0	6	11	0	0	.7	1.2
Institutional average	Jan	1.81	.7	1.3	1.6	2.9	9	16	13	24	0.6	1.1
	Feb	1.86	.6	1.2	1.5	2.9	8	16	15	28	0.6	1.1
	Mar	1.82	.7	1.3	1.6	2.9	8	14	14	25	0.6	1.1

[a] Since food samples were collected from two or more children who were not between the ages of 9–12, data for this month were not used in institutional average.

NS, no sample.

Note: Since iodine-131, barium-140 and strontium-89 were not detectable at most stations during the first quarter of 1968, no provision was made for the nuclides in the table. The few exceptions are as follows: barium-140 was reported in January for Louisiana, 14 pCi/kg. Barium-140 was also reported in March for Idaho, 17 pCi/kg. Strontium-89 was reported in January for Colorado, 6 pCi/kg.

potassium, are reported in g/k of diet and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.83 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1967.

Strontium–90 dietary intake during this period averaged 15 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium–137 intakes averaged 27 pCi/day during this period. Strontium–89, iodine–131 and barium–140 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium–89	5 pCi/kg
Strontium–90	2 pCi/kg
Iodine–131	10 pCi/kg
Cesium–137	10 pCi/kg
Barium–140	10 pCi/kg
Radium–226	0.1 pCi/kg

Data from eight auxiliary stations are included in a separate table (table 2) for general information. These stations do not meet the criterion that the majority of the samples are collected from individuals who range in age from 9–12 years. In order to supplement the existing environmental monitoring networks of the National Center for Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1967	January 1968
July–September 1967	April 1968
October–December and Annual Summary 1967	July 1968

REFERENCES

(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radioassay Procedures for Environmental Samples, PHS Publication No. 999–RH–27. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (January 1967).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Table 2. Concentrations and intake of stable elements and radionuclides in Institutional total diets of individuals (auxilliary stations), January-March 1968

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Juneau	Jan	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Feb	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Mar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Calif: San Francisco	Jan	2.63	0.7	1.8	1.8	4.8	3	8	0	0	0.5	1.3
	Feb	2.83	.6	1.7	1.5	4.2	3	8	13	37	.5	1.4
	Mar	1.92	.7	1.3	1.7	3.3	8	16	14	27	.7	1.3
Miss: Columbia	Jan	1.75	.8	1.4	1.7	2.9	12	21	20	35	.5	0.9
	Feb	2.17	1.0	2.2	1.6	3.5	12	26	12	26	.7	1.5
	Mar	1.92	1.0	1.9	1.6	3.0	10	19	15	29	.6	1.2
Nebr: Omaha	Jan	2.31	.8	1.9	1.7	4.0	8	18	0	0	1.2	2.8
	Feb	2.54	1.0	2.6	1.6	4.1	7	17	11	28	1.8	4.6
	Mar	2.16	.8	1.8	1.4	3.1	6	12	12	26	.9	1.9
Nev: Carson City	Jan	1.79	.5	0.9	1.1	2.0	7	13	0	0	.3	.5
	Feb	1.45	.7	1.0	1.5	2.1	6	9	0	0	.8	1.2
	Mar	1.61	.6	1.0	1.5	2.4	5	7	18	29	.6	1.0
Ore: Portland	Jan	2.45	.7	1.7	1.9	4.8	9	23	11	27	.6	1.5
	Feb	2.34	.4	.9	2.6	6.0	5	13	23	54	.3	.7
	Mar	2.44	.5	1.2	2.0	4.8	5	13	35	85	.5	1.2
N. Mex: Albuquerque	Jan	2.24	.8	1.9	1.6	3.6	4	9	0	0	.4	.9
	Feb	2.22	.8	1.8	1.8	4.0	4	9	0	0	.3	.7
	Mar	2.41	.5	1.3	1.1	2.7	5	12	0	0	.7	1.7
Utah: Salt Lake City	Jan	2.15	.7	1.4	1.3	2.7	4	8	16	34	.5	1.1
	Feb	2.08	.5	1.1	1.2	2.4	6	12	0	0	.5	1.0
	Mar	1.86	.5	.9	1.2	2.2	4	8	0	0	.5	.9
Institutional average	Jan	2.19	0.7	1.6	1.6	3.5	7	14	7	14	0.6	1.3
	Feb	2.23	0.7	1.6	1.7	3.8	6	13	8	21	0.7	1.6
	Mar	2.05	0.7	1.3	1.5	3.1	6	12	13	28	0.6	1.3

NS, no sample.

Note: Since iodine-131, barium-140, and strontium-89 were not detected at most stations during the first quarter of 1968, no provision was made for these nuclides in the table. The few exceptions are as follows: barium-140 was reported in March for Nebraska, 12 pCi/kg. Strontium-89 was reported in January for Oregon, 9 pCi/kg.

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	January–June 1967	June 1968
Colorado River Basin	1965–1966	May 1968
Coast Guard	January–December 1966	November 1967
Radiostrontium in Tap Water, HASL	July–December 1967	June 1968
Florida	1965–1966	July 1968
Washington	July 1966–June 1967	August 1968

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, April 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted

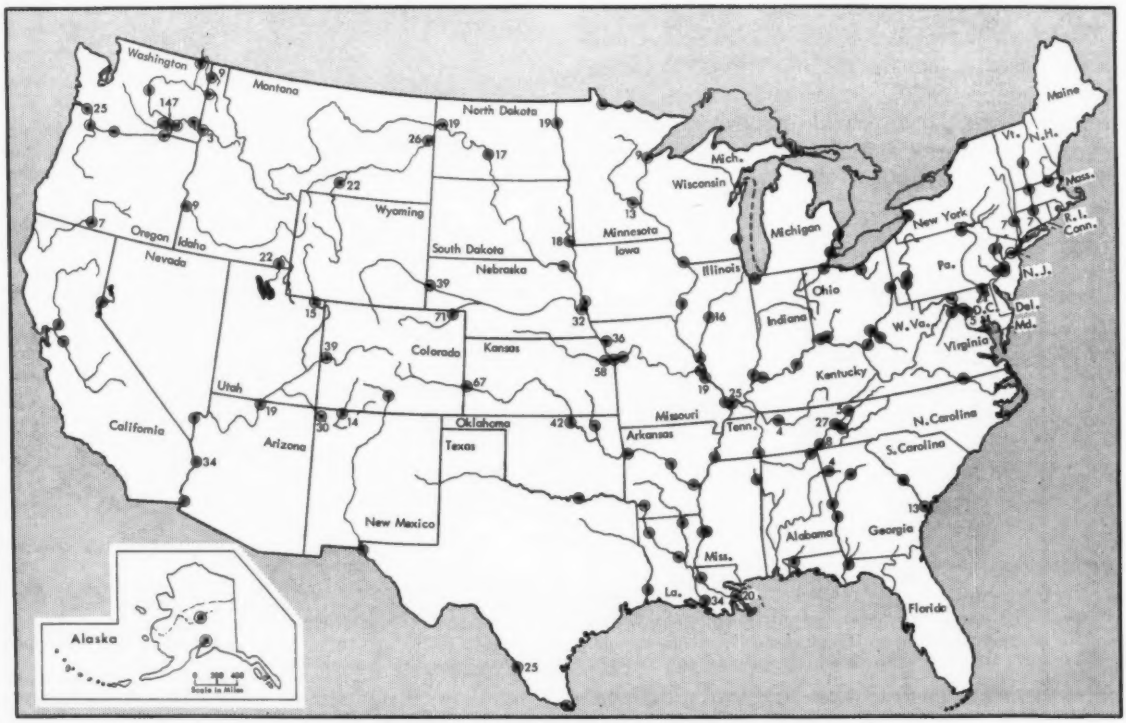

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, April 1968

Table 1. Radioactivity in raw surface waters, April 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	3	1	4	9	5	14
Arkansas River:						
Coolidge, Kans.	4	34	38	13	54	67
Ponca City, Okla.	1	1	2	10	32	42
Atchafalaya River:						
Morgan City, La.	9	1	10	28	6	34
Bear River:						
Preston, Idaho	0	1	1	3	19	22
Big Horn River:						
Hardin, Mont.	0	4	4	0	22	22
Big Sioux River:						
Sioux Falls, S. Dak.	1	3	4	6	12	18
Clearwater River:						
Lewiston, Idaho	0	0	0	1	2	3
Clinch River:						
Clinton, Tenn.	0	1	1	2	3	5
Kingston, Tenn.*	0	<1	<1	1	26	27
Colorado River:						
Loma, Colo.	4	1	5	17	22	39
Page, Ariz.	<1	7	7	2	17	19
Parker Dam, Calif.-Ariz.	0	7	7	0	34	34
Columbia River:						
Pasco, Wash.*	0	1	1	28	119	147
Clatskanie, Ore.	0	<1	<1	8	17	25
Connecticut River:						
Enfield Dam, Conn.	0	0	0	1	6	7
Coosa River:						
Rome, Ga.	<1	0	<1	2	2	4
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	3	4
Great Lakes:						
Duluth, Minn.	0	0	0	1	8	9
Green River:						
Dutch John, Utah	<1	5	5	<1	15	15
Hudson River:						
Poughkeepsie, N.Y.	0	0	0	2	5	7
Illinois River:						
Peoria, Ill.	3	2	5	8	8	16
Kansas River:						
DeSoto, Kans.	4	1	5	42	26	58
Klamath River:						
Keno, Ore.	<1	<1	<1	1	6	7
Mississippi River:						
St. Paul, Minn.	1	2	3	3	10	13
E. St. Louis, Ill.	2	1	3	10	9	19
New Orleans, La.	3	0	3	14	6	20
Missouri River:						
Williston, N. Dak.	1	2	3	4	15	19
Bismarck, N. Dak.	1	3	4	3	14	17
St. Joseph, Mo.	4	1	5	12	24	36
North Platte River:						
Henry, Nebr.	2	16	18	10	29	39
Ohio River:						
Cairo, Ill.	6	1	7	18	7	25
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	1	1	1	8	9
Platte River:						
Plattsmouth, Nebr.	4	5	9	16	16	32
Potomac River:						
Washington, D.C.	0	1	1	1	4	5
Red River, North:						
Grand Forks, N. Dak.	2	<1	2	10	9	19
Rio Grande:						
Laredo, Tex.	4	2	6	15	10	25
San Juan River:						
Shiprock, N. Mex.	6	2	8	20	10	30
Savannah River:						
Port Wentworth, Ga.*	<1	1	1	3	10	13
Snake River:						
Payette, Idaho	1	1	2	<1	9	9
South Platte River:						
Julesburg, Colo.	4	36	40	15	56	71
Tennessee River:						
Chattanooga, Tenn.	0	1	1	1	7	8
Yellowstone River:						
Sidney, Mont.	3	1	4	5	21	26
Maximum	9	36	40	42	119	147
Minimum	0	0	0	0	2	3

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During April 1968, the following stations showed concentrations in excess of 15 pCi/liter of alpha radioactivity on dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Tritium in Surface Water Network, 1967

National Center for Radiological Health
U.S. Public Health Service

A tritium sampling network was established by the Public Health Service in May 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at selected surface water stations downstream from nuclear facilities. The network consists of 10 stations selected from the 131 existing water pollution sampling stations operated by the Federal Water Pollution Control Administration (FWPCA); eight of the stations are located downstream from nuclear facilities and two stations serve to establish baseline levels (figure 1). Reports covering the periods, 1964–1965 (*1*) and 1966 (*2*) have been published previously in *Radiological Health Data and Reports.*

Monthly composites of weekly samples are collected through the FWPCA and sent to the Southeastern Radiological Health Laboratory for analysis. The analyses are carried out using liquid scintillation counting techniques described by Moghissi et al. (*3*). The minimum level of detectability is 0.2 nCi/liter.

Data for the samples collected during 1967 are shown in table 1. Station averages for the year are also presented. The highest concentration observed during 1967 was 16.9 nCi/liter at the Port Wentworth, Ga. station (Savannah River). The highest yearly average, 7.0 nCi/liter, was also observed at the Port Wentworth station. Assuming that the specific activity of tritium in the body is essentially the same as that in the surface water, this average concentration corresponds to an estimated whole-body dose[1] of 1.2 mrem/yr; or in terms of Federal Radiation Council guidance, 0.7 percent of the Radiation Protection Guide (170 mrem/yr) for an average dose to a suitable sample of the exposed population (*4*).

[1] Development of the calculations to obtain this dose may be found in reference (*2*).

Figure 1. Sampling stations for tritium in surface waters

Table 1. Tritium concentration of surface waters, 1967

Collection site	Concentration [a] (nCi/liter)						
	January	February	March	April	May	June	Average [b]
Big Sioux River, Sioux Falls, S. Dak.	0.7±0.3	2.0±0.3	1.4±0.2	1.1±0.2	1.3±0.2	0.7±0.2	
Clinch River, Kingston, Tenn.	1.3±0.3	5.8±0.3	3.1±0.3	2.9±0.3	10.8±0.5	2.5±0.3	
Colorado River, Boulder City, Nev.	2.4±0.3	2.8±0.3	2.9±0.3	3.0±0.3	2.3±0.3	2.0±0.3	
Columbia River, Northport, Wash. [c]	1.4±0.3	1.8±0.3	1.8±0.3	1.7±0.2	1.8±0.2	1.4±0.2	
Columbia River, Pasco, Wash.	1.6±0.3	1.8±0.3	1.5±0.3	1.7±0.2	1.5±0.2	1.1±0.2	
Hudson River, Poughkeepsie, N.Y.	1.0±0.4	1.2±0.2	1.0±0.3	NS	NS	1.2±0.2	
Mississippi River, New Orleans, La. [c]	[d]0.2±0.2	1.0±0.3	0.8±0.3	1.0±0.2	0.8±0.2	0.7±0.2	
Ohio River, Toronto, Ohio	NS	NS	NS	NS	NS	0.8±0.2	
Rio Grande, El Paso, Tex.	NS	NS	0.9±0.3	NS	0.6±0.2	0.5±0.2	
Savannah River, Port Wentworth, Ga.	6.3±0.4	7.6±0.3	16.9±0.5	9.9±0.3	6.2±0.4	3.7±0.3	
	July	August	September	October	November	December	
Big Sioux River: Sioux Falls, S. Dak.	1.0±0.2	1.0±0.2	0.6±0.2	0.8±0.2	0.6±0.2	<0.2	0.9
Clinch River, Kingston, Tenn.	NS	2.0±0.2	2.2±0.2	2.3±0.3	4.7±0.2	16.0±0.8	4.9
Colorado River, Boulder City, Nev.	2.4±0.3	2.3±0.3	2.3±0.3	2.1±0.3	2.5±0.2	2.4±0.2	2.5
Columbia River, Northport, Wash. [c]	1.0±0.2	1.0±0.2	NS	NS	NS	NS	1.5
Columbia River, Pasco, Wash.	1.4±0.2	0.8±0.2	1.0±0.2	NS	NS	NS	1.4
Hudson River, Poughkeepsie, N.Y.	NS	NS	0.8±0.2	0.8±0.2	1.0±0.2	0.5±0.2	0.9
Mississippi River, New Orleans, La. [c]	0.6±0.2	0.4±0.2	0.6±0.2	0.8±0.2	0.8±0.2	[d]0.2±0.2	0.6
Ohio River, Toronto, Ohio	0.6±0.2	NS	NS	NS	NS	NS	0.7
Rio Grande, El Paso, Tex.	0.5±0.2	0.4±0.2	0.5±0.2	0.4±0.2	<0.2	<0.2	0.4
Savannah River, Port Wentworth, Ga.	4.5±0.2	8.0±0.2	4.7±0.3	4.2±0.3	8.6±0.4	3.6±0.2	7.0

[a] The error reported is the two-sigma error at the 95-percent confidence level.
[b] Values less than or equal to the minimum level of detectability (0.2 nCi/liter) were averaged as zero.
[c] Baseline station.
[d] Values are not statistically significant at the 95-percent confidence level.
NS, no sample.

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(1) CHESNUTT, M. W., J. C. DROBINSKI, JR., and R. H. GORRIE. Tritium in surface waters, 1964–1965. Radiol Health Data Rep 7:377–380 (July 1966).

(2) MOGHISSI, A. A., and C. R. PORTER. Tritium in surface waters of the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(3) MOGHISSI, A. A., H. L. KELLEY, J. E. REGNIER, and M. W. CARTER. Low level tritium counting by means of liquid scintillation. (To be published.)

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Radioactivity in Minnesota Municipal Water Supplies[1] July-December 1967

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul and monthly at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from July–December 1967. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha radioactivity reported as <1 pCi/liter was considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 6 to 24 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

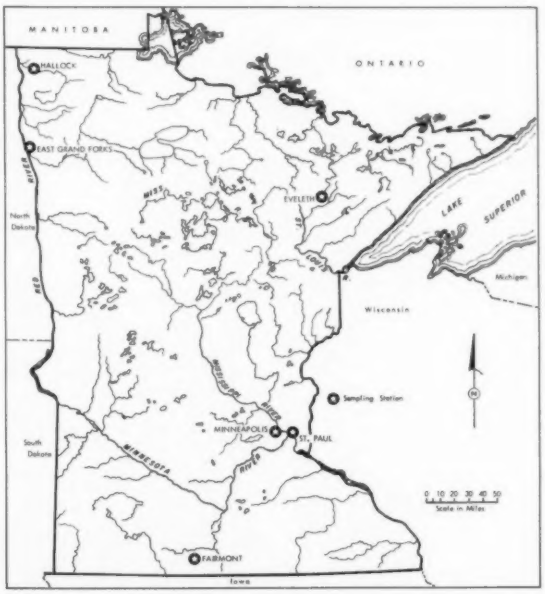

Figure 1. Minnesota surface water sampling locations

[1] Data and information from "Survey of Environmental Radioactivity, July–December 1967," Publication No. COO–651–56. State of Minnesota Department of Health, University Campus, Minneapolis, Minn. 55440.

Table 1. Beta radioactivity in Minnesota raw and treated water supplies, July–December 1967

Town and water source	Type of water	Average concentrations (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	24	15	22	16	20	21
	Treated	16	15	22	16	12	23
East Grand Forks, Red Lake River	Raw	18(4) [a]	16(4)	13(4)	15(5)	13(4)	17(3)
	Treated	11(4)	10(4)	8(4)	8(5)	7(4)	8(3)
Eveleth, St. Mary's Lake	Raw	11(4)	13(5)	10(4)	11(4)	14(5)	11(4)
	Treated	11(4)	14(5)	11(4)	12(4)	12(5)	12(4)
Fairmont, Budd Lake	Raw	11(5)	13(4)	11(4)	13(5)	12(4)	14(3)
	Treated	6(5)	9(4)	8(4)	9(5)	7(4)	9(3)
Hallock, Two Rivers South Fork	Raw	21(4)	19(5)	12(4)	17(2)	21(5)	21(3)
	Treated	8(4)	9(5)	6(4)	6(2)	8(5)	10(3)
International Falls, Rainy River	Raw	11	7	9	7	9	8
	Treated	7	6	9	7	7	7
Minneapolis tap water	Raw						
	Treated	6(5)	5(4)	5(4)	5(5)	3(4)	4(4)
St. Cloud, Mississippi River	Raw	10	9	8	6	9	10
	Treated	7	4	5	9	5	4
St. Paul, Vadnais Chain of Lakes	Raw	11(4)	13(5)	6(4)	10(4)	9(5)	9(4)
	Treated	7(4)	9(5)	6(4)	7(4)	6(5)	6(4)

[a] Number in parentheses gives number of samples averaged.

Table 2. Alpha radioactivity in Minnesota raw and treated water supplies, July–December 1967

Town and water source	Type of water	Average concentrations (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	1	1	<1	<1	2	2
	Treated	2	<1	<1	<1	<1	<1
East Grand Forks, Red Lake River	Raw	2(4) [a]	<1(4)	2(4)	<1(5)	1(4)	<1(3)
	Treated	<1(4)	<1(4)	1(4)	<1(5)	<1(4)	<1(3)
Eveleth, St. Mary's Lake	Raw	<1(4)	<1(5)	<1(4)	<1(4)	1(5)	<1(4)
	Treated	<1(4)	<1(5)	<1(4)	<1(4)	<1(5)	<1(4)
Fairmont, Budd Lake	Raw	4(5)	4(4)	4(4)	3(5)	3(4)	4(3)
	Treated	<1(5)	<1(4)	<1(4)	<1(5)	<1(4)	1(3)
Hallock, Two Rivers South Fork	Raw	<1(4)	2(5)	<1(4)	2(2)	1(5)	2(3)
	Treated	1(4)	<1(5)	<1(4)	2(2)	<1(5)	1(3)
International Falls, Rainy River	Raw	<1	<1	<1	<1	<1	<1
	Treated	<1	<1	<1	<1	<1	<1
Minneapolis tap water	Raw						
	Treated	1(5)	<1(4)	<1(4)	<1(5)	<1(4)	<1(4)
St. Cloud, Mississippi River	Raw	1	2	<1	<1	<1	<1
	Treated	<1	<1	<1	<1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1(4)	<1(5)	<1(4)	<1(4)	<1(5)	<1(4)
	Treated	<1(4)	<1(5)	1(4)	<1(4)	<1(5)	<1(4)

[a] Number in parentheses gives number of samples averaged.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	January 1968

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, Public Health Service Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Radioactivity in New York Surface Water, June–December 1967

Division of General Engineering and Radiological Health
State of New York Department of Health

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 27 locations for gross beta radioactivity analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger samples are collected at selected locations for strontium–90 analysis.

Analytical procedures

Strontium and other alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1, 2*).

Strontium–90 is determined by yttrium–90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium–89 is estimated by taking the difference between the total strontium and the strontium–90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95–percent confidence level.

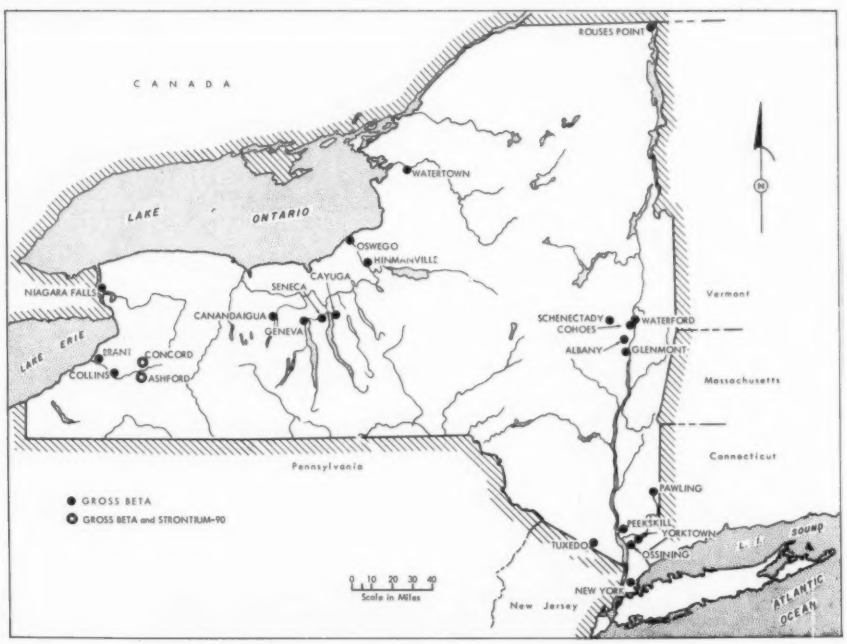

Figure 1. New York water sampling locations

Table 1. Gross beta radioactivity in New York raw surface water, June- December 1967

Location	Sampling [a]	Gross beta radioactivity (pCi/liter)						
		June	July	Aug	Sept	Oct	Nov	Dec
Albany	BW	5	3	NS	NS	NS	NS	2
Ashford (Buttermilk Creek at Thomas Corners)	W	1,052(3) [b]	1,782(3)	561(4)	1,819(5)	1,129(4)	499(2)	NS
Brant (Cattaraugus Creek)	W	24(2)	79(4)	39(5)	41(4)	58(4)	54(5)	20
Cohoes (Mohawk River)	D	NS	NS	NS	3(3)	3(4)	3(4)	3(2)
Collins (Cattaraugus Creek)	M	41(2)	66(4)	42(5)	64(4)	51(4)	46(5)	89
Concord (Cattaraugus Creek)	D	87(11)	118(17)	82(22)	115(13)	110(18)	124(18)	153(19)
Geneva (Seneca Lake)	SA	NS	NS	NS	NS	3	NS	NS
Glenmont (Hudson River)	D	NS	4	4	3(3)	3(3)	2(4)	3(4)
Lansing	SA	NS	NS	1(5)	NS	NS	NS	NS
New York City	SA	NS	NS	NS	NS	3(2)	3	NS
Niagara Falls (East Branch-Niagara River)	Q	NS	4	4	NS	NS	NS	NS
(West Branch-Niagara River)	Q	NS	4	NS	4	5	1	0
Ossining (Hudson River)	D	26(4)	24(4)	19(5)	40(3)	37(5)	8(4)	7
(Indian Brook Reservoir)	M	NS	24(2)	4	4	3	5	NS
Oswego (Lake Ontario)	M	NS	NS	4	NS	3	NS	NS
Pawling (Pond at United Nuclear)	M	NS	NS	4	3(2)	NS	3	2
Peekskill (Camp Field water supply)	M	NS	NS	3	8	1	1	4
(Hudson River)	D	8(3)	10(4)	10(4)	18(4)	20(5)	5(4)	4(4)
Schenectady (Mohawk River)	C	NS	3(3)	4(4)	3(5)	3(5)	1(3)	3
Tuxedo (Indian Hill)	M	NS	NS	5	3	4	3	0
Watertown (Black River)	BW	5	NS	3	3	3(3)	4(2)	2(2)
Yorktown (Croton Reservoir)	M	NS	NS	5	3	NS	4	NS

[a] BW, Biweekly composite of daily grab samples.
W, weekly sample.
D, weekly composite of daily grab samples.
C, continuous bleed-off analyzed weekly.
M, monthly grab sample.
Q, quarterly grab sample.
SA, semiannual grab sample.
[b] Figures in parentheses are number of samples in average.
NS, no sample.

Discussion and results

The observed gross beta-particle concentrations in New York surface water for June–December 1967 are given in table 1. The Ashford station at Thomas Corners, Brant, Collins and Concord stations are located downstream from the Nuclear Fuels Services reprocessing plant and show concentration levels well above natural background. The higher gross beta radioactivity levels in water at the Peekskill and Ossining stations reflect the intrusion of saline water at those points.

The average concentrations of strontium–89 and strontium–90 in New York water for June through December 1967 for the Ashford and Concord stations are given in table 2.

Table 2. Strontium–90 in New York surface waters [a] June-December 1967

Location	Month (1967)	Strontium-90 (pCi/liter)
Ashford (Cattaraugus Creek at Bigelow Bridge)	June	<3
	July	<3
	August	8
	September	<3
	October	<3
	November	<3
	December	NA
Concord [b] (Springville Power Dam on Cattaraugus Creek)	August	15
	September	26
	October	<3
	November	NA
	December	NA

[a] No analysis was done for strontium-89 for these periods.
[b] These samples were collected from a sampling station located downstream from the Nuclear Fuel Services spent fuel processing plant located in Cattaraugus County.
NA, no analysis.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1966	September 1967
January–May 1967	January 1968

REFERENCES

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(2) WELFORD, G., and D. SUTTON, a paper presented at the American Chemical Society meeting in New York City, September 1960.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
80th Meridian Network, HASL	July–December 1967	September 1968
Fallout Network, HASL	Calendar Year 1965	January 1967

1. Radiation Alert Network June 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1968

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Pptn	Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	1	4.61	1.05	2.23	Sept 68	40	1	40	45
Alaska:	Adak	30		1.43	.36	.91	Apr 68	[c]			
	Anchorage	17		.00	.00	.00	Oct 68	[c]			
	Attu Island	[b]					May 68	[c]			
	Fairbanks	17	12	.75	.00	.20	Jan 68	38	12	38	10
	Juneau	18	9	.00	.00	.00	Feb 68	55	9	55	0
	Kodiak	16		1.87	.16	.60	Mar 68	[c]			
	Nome	[b]					July 68	[c]			
	Point Barrow	25		1.49	1.14	1.23	June 68	[c]			
	St. Paul Island	29		.93	.43	.45	Aug 68	[c]			
Aris:	Phoenix	19		21.24	1.61	6.15	Feb 68	[c]			
Ark:	Little Rock	9	2	2.02	.25	1.26	Oct 68	115	2	115	0
Calif:	Berkeley	19		.82	.00	.24	Mar 68	[c]			
	Los Angeles	19		1.72	.27	.68	July 68	[c]			
C. Z:	Ancon	11		3.01	1.29	2.11	Mar 68	[c]			
Colo:	Denver	20		5.32	1.23	2.86	Mar 68	86	[d]		
Conn:	Hartford	20	12	.52	.23	.30	Jan 68	139	12	139	0
Del:	Dover	20		1.06	.17	.53	Sept 68	[c]			
D. C:	Washington	20	9	2.04	.30	.99	June 68	114	9	114	9
Fla:	Jacksonville	20	4	1.05	.00	.51	Oct 68	77	0	0	[c]
	Miami	16	7	.24	.08	.18	Jan 68	233	7	233	0
Ga:	Atlanta	18		1.24	.78	1.01	Aug 68	[c]			
Guam:	Agana	19		.67	.22	.49	Sept 68	[c]			
Hawaii:	Honolulu	30		.66	.31	.61	May 68	91	[d]		
Idaho:	Boise	20	3	12.89	.38	1.60	May 68	19	3	19	0
Ill:	Springfield	18		5.50	.55	2.50	June 68	[c]			
Ind:	Indianapolis	20	3	2.92	.60	1.57	Aug 68	43	3	43	111
Iowa:	Iowa City	19		4.31	.65	1.50	Mar 68	[c]			
Kans:	Topeka	20	5	4.76	.61	1.92	Oct 68	85	5	85	0
Ky:	Frankfort	12	3	4.29	.36	1.26	June 68	22	3	22	10
La:	New Orleans	20		1.01	.24	.53	June 68	[c]			
Maine:	Augusta	21	14	.79	.18	.37	July 68	145	14	145	0
Md:	Baltimore	20	5	2.94	.35	.96	Jan 68	4	5	4	0
	Rockville	16	1	1.06	.34	.61	May 68	106	[d]		
Mass:	Lawrence	11	10	.85	.00	.49	Sept 68	147	0	0	[c]
	Winchester	20	14	1.60	.00	.34	Apr 68	134	14	134	0
Mich:	Lansing	20	11	4.56	.58	1.87	May 68	144	11	144	1,278
Minn:	Minneapolis	19	11	1.20	.07	.27	Sept 68	154	11	154	
Miss:	Jackson	18	3	2.29	.22	.76	July 68	49	3	49	
Mo:	Jefferson City	20	5	3.55	.54	1.42	Aug 68	70	5	70	
Mont:	Helena	16	7	2.64	.36	.93	Apr 68	50	7	50	
Nebr:	Lincoln	19		3.89	.30	1.60	Aug 68	[c]			
Nev:	Las Vegas	18		2.94	.47	1.55	Jan 68	[c]			
N. H:	Concord	20		1.62	.44	.76	June 68	[c]			
N. J:	Trenton	19	6	2.54	.39	.74	July 68	138	6	138	
N. Mex:	Sante Fe	17		19.60	.24	1.52	Apr 68	[c]			
N. Y:	Buffalo	[b]					Aug 68	[c]			
	New York City	17		1.47	.31	.73	Mar 68	[c]			
N. C:	Gastonia	18		.39	.16	.25	Apr 68	[c]			
N. Dak:	Bismarck	16		8.71	1.41	3.37	Mar 68	45	[d]		
Ohio:	Cincinnati	19		2.17	.27	.88	June 68	[c]			
	Columbus	[b]					Sept 68	[c]			
	Painesville	17	4	2.46	.35	1.05	July 68	86	2	37	0
Okla:	Oklahoma City	20	6	1.45	.00	.61	Jan 68	54	6	54	0
	Ponca City	17	2	4.03	.00	1.64	May 68	44	2	44	182
Ore:	Portland	19	4	2.10	.08	.57	Jan 68	50	4	50	0
Pa:	Harrisburg	20	5	1.50	.21	.40	Aug 68	31	5	31	0
P. R:	San Juan	15	1	2.48	.37	.83	Aug 68	25	0	0	[c]
R. I:	Providence	[b]					July 68	[c]			
S. C:	Columbia	9		.31	.15	.26	May 68	[c]			
S. Dak:	Pierre	17		.95	.20	.42	Apr 68	[c]			
Tenn:	Nashville	4		1.55	.73	1.02	Feb 68	[c]			
Tex:	Austin	17	1	2.27	.42	1.19	May 68	12	1	1	0
	El Paso	15		5.64	.38	1.88	Sept 68	77	[d]		
Utah:	Salt Lake City	20		5.23	.96	2.09	June 68	[c]			
Vt:	Barre	29	2	2.19	.51	1.22	July 68	12	0	0	[c]
Va:	Richmond	20	12	1.89	.21	.86	Oct 68	92	12	92	4
Wash:	Seattle	12	1	.74	.18	.50	Oct 68	19	0	0	[c]
	Spokane	22		.00	.00	.00	Oct 68	71	[d]		
W. Va:	Charleston	20	4	2.87	.63	1.50	Sept 68	7	0	0	[c]
Wisc:	Madison	19	7	2.19	.24	.85	Apr 68	47	7	47	24
Wyo:	Cheyenne	20	9	2.08	.00	.82	Oct 68	190	9	190	180
		20	2	5.61	.91	2.83	Jan 68	19	2	19	20
Network summary		1,257	217	21.24	0.00	1.10		75	6	79	76

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received (air samples submitted without field estimate data are not considered by the data program).
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. Gross beta analysis is not done.
[e] Samples were collected but no field estimates were reported.

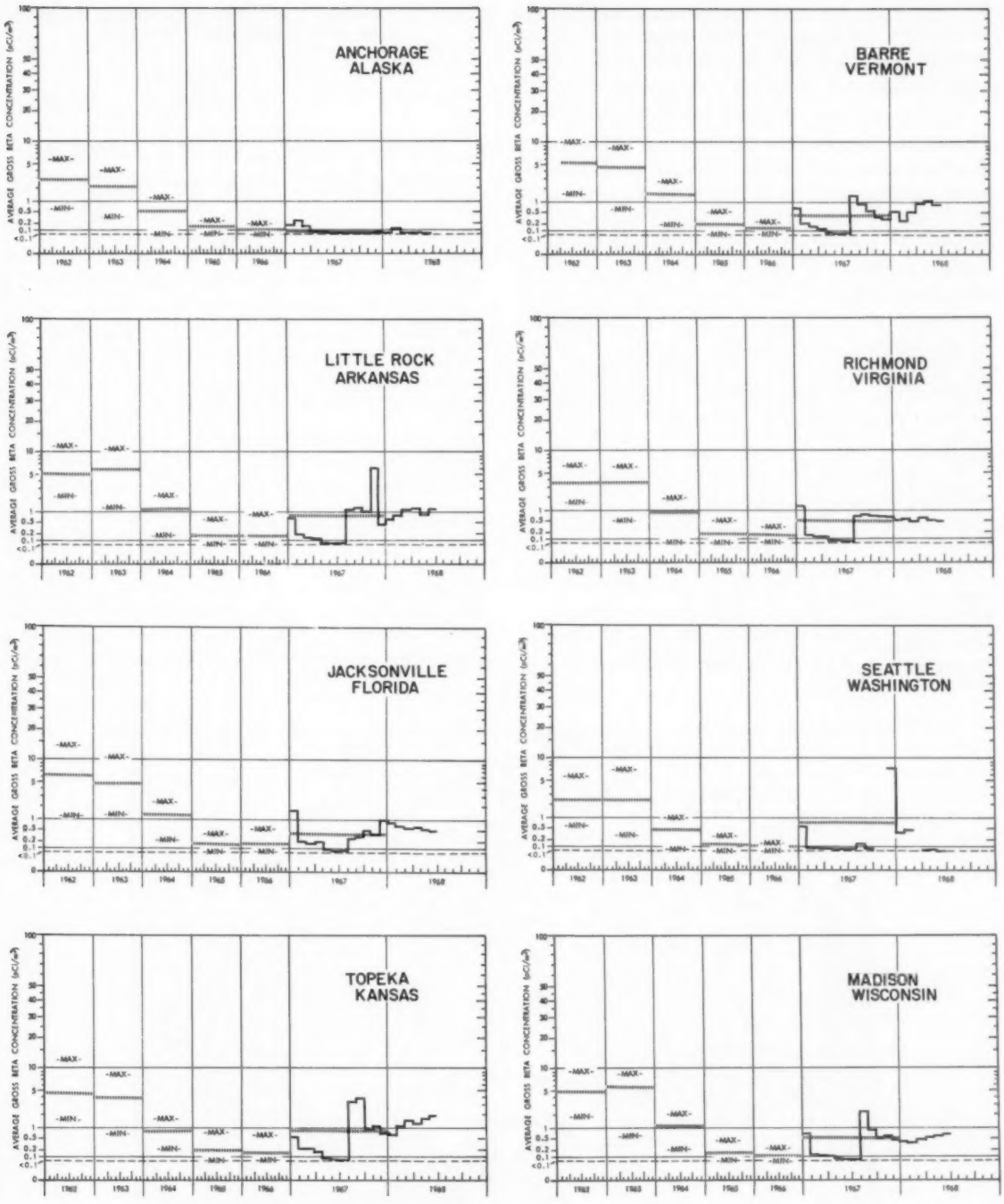

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–June 1968

2. Canadian Air and Precipitation Monitoring Program[1], June 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for June 1968 are presented in table 2.

[1] Prepared from information and data in the July 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi m²)
Calgary	30	0.5	0.0	0.2	97	5.3
Coral Harbour	28	.2	.0	.1	51	2.5
Edmonton	30	.3	.0	.2	129	8.8
Ft. Churchill	29	.4	.0	.1	96	3.0
Ft. William	30	.3	.0	.1	81	9.0
Fredericton	29	.4	.0	.1	65	5.6
Goose Bay	30	.3	.0	.1	95	5.8
Halifax	29	.2	.0	.0	48	6.6
Inuvik	30	.2	.0	.1	497	1.1
Montreal	30	.4	.0	.2	113	9.7
Moosonee	30	.4	.0	.2	32	2.9
Ottawa	30	.4	.0	.2	81	8.6
Quebec	29	.3	.0	.1	93	6.1
Regina	30	.4	.0	.2	208	2.9
Resolute	24	.1	.0	.0	20	0.3
St. John's, Nfld.	30	.2	.0	.1	44	6.8
Saskatoon	30	.3	.0	.2	144	5.4
Sault Ste Marie	25	.5	.0	.2	116	11.1
Toronto	29	.4	.0	.2	87	6.5
Vancouver	30	.3	.0	.1	72	4.9
Whitehorse	30	.2	.0	.1	NS	NS
Windsor	29	.3	.0	.2	45	6.8
Winnipeg	30	.3	.0	.2	115	9.5
Yellowknife	30	.4	.0	.2	160	2.2
Network summary	29	0.3	0.0	0.1	108	5.8

NS, no sample.

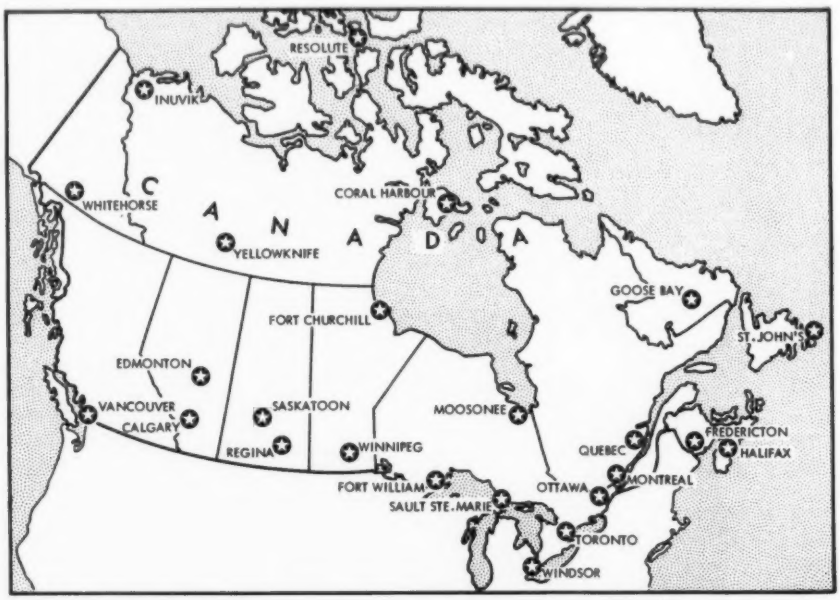

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program June 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNE.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirrección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision de Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desrérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during June 1968 are presented in table 3.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, June 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Acapulco	NS	NS	NS	NS
Chihuahua	2	0.4	0.3	—
Ciudad Juarez	5	.5	.2	0.4
Ensenada	NS	NS	NS	NS
Guadalajara	NS	NS	NS	NS
Guaymas	NS	NS	NS	NS
La Paz	15	.5	.1	.4
Matamoros	NS	NS	NS	NS
Mazatlán	7	1.2	0.2	.5
Mérida	15	.4	.1	.2
México, D. F.	1	.1	.1	—
Nuevo Laredo	3	.1	.1	.1
San Luis Potosí	NS	NS	NS	NS
Tampico	12	.5	<.1	.1
Terreón	11	.3	.1	.2
Veracruz	2	.1	.1	—

NS, station temporarily shut down, no sample.

4. Pan American Air Sampling Program June 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. Analytical techniques were described in the March 1968 *Radiological Health Data and Reports*. The June 1968 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, June 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	12	0.06	0.01	0.02
Bolivia: La Paz	16	.04	.01	.03
Chile: Santiago	30	.38	.01	.04
Colombia: Bogota	18	.01	.00	.01
Ecuador: Guayaquil	18	.03	.02	.02
Jamaica: Kingston	19	.14	.02	.08
Peru: Lima	13	.04	.01	.03
Venezuela: Caracas	16	.61	.02	.13
West Indies: Trinidad	17	.12	.01	.07
Pan American summary	159	0.61	0.00	0.05

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 5. Pan American Air Sampling Program stations

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. National Center for Radiological Health, Standards and Intelligence Branch, Rockville, Md. 20852 (Distribution by official request).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(*5*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*7*) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity in Mexico, January–June 1967

Comisión Nacional de Energía Nuclear

The Dirección General de Seguridad Radiológica of the Comisión Nacional de Energía Nuclear (CNEN) in Mexico through its Environmental Activity Section operates surveillance networks monitoring airborne particulates, rainwater, drinking water, milk, food and sea water.

Samples are collected at sampling stations located throughout the Mexican Republic with emphasis given to the Nuclear Center site and its surroundings (Nuclear Center is still under construction). Sampling, analytical and counting techniques have been described (*1*). The location of sampling stations in the Mexican Republic is shown in figure 1. The tables present radioactivity levels for the first half of 1967.

Radioactivity of particulates in air is summarized in tables 1 and 2. Gross beta radioactivity of airborne particulates is given for 17 stations in table 1. Results of a special study on radiochemical separations of particulates in air for strontium–90, cesium–137 and potassium–40 are shown in table 2 at four locations.

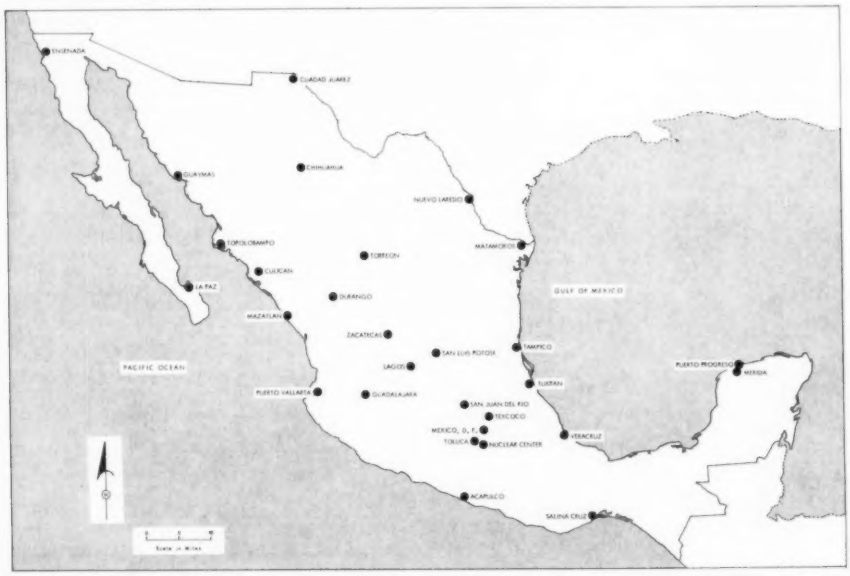

Figure 1. Location of sampling stations in the Mexican Republic

Table 1. Gross beta radioactivity of airborne particulates, Mexico, January–June 1967

Station	Average gross beta radioactivity concentration (pCi/m³)					
	Jan	Feb	Mar	Apr	May	June
Acapulco	0.1	0.2	0.3	0.3	0.1	0.1
Chihuahua	.2	.2	.3	.2	.1	.1
Ciudad Juárez	3.2	.3	.3	.2	.1	<.1
Ensenada	.2	.3	.3	.1	.1	.1
Guadalajara	.1	NS	.1	.1	NS	.1
Guaymas	.3	NS	NS	NS	NS	NS
La Paz	.1	.6	.4	.2	.1	.1
Matamoros	NS	NS	NS	NS	NS	NS
Mazatlán	.1	.3	.5	.2	.1	.1
Mérida	.3	.2	.1	.1	.1	.1
México, D. F.	.1	.1	.1	.1	.1	.1
Nuevo Laredo	.1	.1	.2	.1	.1	NS
San Luis Potosí	<.1	NS	NS	NS	NS	NS
Tampico	.1	NS	.1	.1	.1	NS
Torreón	.2	.2	.3	.1	.1	<.1
Veracruz	.1	.1	NS	.1	.1	.1
Nuclear Center	.1	NS	NS	NS	<.1	.1

NS, no sample.

Table 2. Radiochemical analysis of particulates in composite air samples, Mexico, January–June 1967

Station	Date	Potassium-40 (pCi/10,000 m³)	Strontium-90 (pCi/10,000 m³)	Cesium-137 (pCi/10,000 m³)
Chihuahua	Jan–Feb	33.9	3.4±0.1	3.4±0.1
	Mar–Apr	9.7	3.7±0.1	20.7±4.0
	May–June	9.3	3.4±1.2	8.3±2.0
Cuidad Juáres	Jan–Feb	4.9	3.0±0.1	21.0±0.1
Mérida	Jan–Feb	21.0	4.0±0.1	15.0±0.1
	Mar–Apr	8.3	3.2±0.6	20.8±4.0
	May–June	9.1	9.0±1.3	20.2±4.0
México, D. F.	Jan–Feb	36.0	2.8±0.1	7.8±0.5
	Mar–Apr	10.3	2.9±0.2	14.4±3.0
	May–June	8.6	3.0±0.5	7.9±2.0

Except for a special study, radiochemical separations are made only on samples containing daily concentrations greater than 1 pCi/m³.

Table 3 shows the beta radioactivity in rainwater at five locations. Table 4 shows gross beta radioactivity in Mexico City drinking water and drinking river and lake water in various locations near the Nuclear Center. Drinking water is sampled weekly in Mexico City and monthly from areas around the Nuclear Center.

Strontium–90 concentrations in liquid milk samples collected at ten locations and powdered milk samples collected at two locations are given in table 5. Milk samples are collected from different locations in Mexico with several sampling locations near Mexico City and the Nuclear Center. Gross beta radioactivity and strontium–90 values in foods are given in tables 6 and 7.

Table 6 shows gross beta radioactivity values in foods collected primarily from the Mexico

Table 3. Gross beta radioactivity in rainwater, Mexico, January–June 1967

Station	Concentrations and deposition of gross beta radioactivity	Sample fraction [a]	1967					
			Jan	Feb	Mar	April	May	June
Chihuahua	pCi/liter	SS	4.9	0.6		1.5	12.7	3.0
		DS	3.6	6.7		19.3	8.9	3.0
	nCi/m³	SS	.1	.2		.1	.3	.1
		DS	.1	.3		1.2	.1	.1
Mérida	pCi/liter	SS			31.3	3.0	3.0	4.0
		DS			33.7	3.0	3.0	3.0
	nCi/m³	SS			4.2	.3	.3	.3
		DS			4.5	.4	.2	.1
México, D. F.	pCi/liter	SS	3.0	38.0	36.8	8.7	15.8	3.0
		DS	4.0	28.1	5.6	3.0	3.0	3.0
	nCi/m³	SS	.4	.3	.2	.3	2.2	.4
		DS	.6	.2	.3	.3	.1	.3
Torreón	pCi/liter	SS	15.0	18.4	10.2			
		DS	10.5	13.9	3.4			
	nCi/m³	SS	.2	.2	.4			
		DS	.1	.2	.1			
Nuclear Center	pCi/liter	SS			19.4	3.0	4.3	3.0
		DS			12.1	5.8	3.0	3.0
	nCi/m³	SS			2.3	.4	.1	.1
		DS			1.4	.8	.1	.2

[a] SS, suspended solids.
DS, dissolved solids.

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- 599 MISSING IN NUMBERING ONLY

Table 4. Gross beta radioactivity in Mexico City drinking water and in lake, river, and drinking water near the Nuclear Center

Station	Sample fraction [a]	Average concentrations (pCi/liter)					
		1967					
		January	February	March	April	May	June
México, D. F.	SS		<3	<3	<3	<3	<3
	DS		4.2	<3	2.7	2.7	1.3
Colonial Ortiz Rubio	SS		<3	<3	<3	<3	<3
	DS		2.5	<3	<3	1.6	3
Cuajimlapa	SS			<3	<3	<3	<3
	DS			<3	<3	<3	<3
Huixquilucan	SS		<3	<3	<3	<3	<3
	DS		2.6	<3	<3	<3	<3
Laguana Salazar	SS			<3	<3	<3	<3
	DS			1.2	<3	<3	<3
Lerma De Villada	SS	<3	9.9	<3	<3	<3	<3
	DS	<3	11.0	<3	<3	6.0	11.8
Ocoyoacac	SS		<3	<3	3.4	1.8	<3
	DS		<3	<3	<3	1.2	<3
San Ignacio Allende	SS		9.9	<3	5.1	<3	<3
	DS		11.0	<3	<3	2.0	<3
San Mateo Atarasquillo	SS	<3		<3	<3	<3	<3
	DS	<3		5.6	<3	1.4	<3
San Miquel Ameyalco	SS	<3		1.4	<3	<3	<3
	DS	3.2		1.9	<3	<3	<3
San Pedro Atlapulco drinking water	SS			<3	<3	<3	<3
	DS			5.7	<3	1.6	<3
river water	SS			<3	1.4		<3
	DS			5.7	<3		<3

[a] SS, suspended solids.
DS, dissolved solids.

City area and around the Nuclear Center during the first half of 1967. Table 7 gives radioactivity values for some foods that have been harvested prior to 1967. The most elevated beta radioactivity values were detected in horsebeans.

Radiochemical analyses of beta radioactivity in sea water samples taken near sites of six ports are shown in table 8. Samples are taken 5 kilometers from shore near ports of the Pacific Ocean and the Gulf of Mexico. If sea water samples contain gross beta radioactivity greater than one-tenth of the maximum permissible concentration for drinking water, they are analyzed for strontium–90 and cesium–137.

Table 5. Strontium–90 in milk, Mexico, January–June 1967

Station	Strontium-90 concentration of monthly composite	January	February	March	April	May	June
Chalco	pCi/liter	<1	<1	<1	<1	1.4±0.6	<1
	pCi/g Ca	<1	<1	<1	<1	1.0±0.4	<1
Chihuahua	pCi/liter	1.4±0.5	<1	<1	<1	15.5±1.4	8.8±0.7
	pCi/g Ca	1.5±0.5	<1	<1	<1	9.1±0.8	5.5±0.4
Coapa	pCi/liter	<1	<1	<1	<1	<1	<1
	pCi/g Ca	<1	<1	<1	<1	<1	<1
Huixilucan	pCi/liter	3.9±0.7	<1	<1	<1	<1	2.8±0.2
	pCi/g Ca	2.6±0.4	<1	<1	<1	<1	2.0±0.1
Mérida	pCi/liter			<1	1.0±0.5		<1
	pCi/g Ca			<1	0.7±0.4		<1
San Juan Del Río	pCi/liter						<1
	pCi/g Ca						<1
San Mateo Atarasquiello	pCi/liter					1.2±0.7	2.3±0.4
	pCi/g Ca					0.6±0.4	1.8±0.3
Texcoco	pCi/liter	<1	<1	<1	<1	<1	<1
	pCi/g Ca	<1	<1	<1	<1	<1	<1
Toluca	pCi/liter	1.2±0.4	3.6±0.5	1	1	9.2±1.2	2.4±1.5
	pCi/g Ca	1.0±0.3	2.8±0.4	1	1	6.1±0.8	2.3±1.4
Veracrus	pCi/liter	1.5±1.0	1.4±0.2	<1	1.4±0.4	<1	<1
	pCi/g Ca	1.3±0.7	1.1±0.16	<1	0.8±0.2	<1	<1
Lagos [a]	pCi/liter	<1	<1	<1	<1	1.1±0.7	2.0±0.7
	pCi/g Ca	<1	<1	<1	<1		1.6±0.6
Tamuin [a]	pCi/liter			<1	<1		
	pCi/g Ca			<1	<1		

[a] Powdered milk sampling station.

Table 6. Gross beta radioactivity in foods, Mexico

Food	Sampling location	Date of collection	Gross radioactivity (pCi/kg) dry base
Beans	Huixquilucan	3/29/67	1,776
Horsebeans	Huixquilucan	3/29/67	14,435
	San Ignacio Allende	3/29/67	14,741
Corn	Huixquilucan	3/29/67	4,858
Pulque	Huixquilucan	2/22/67	345
	San Ignacio Allende	1/5/67	295
		2/22/67	116
		3/30/67	598
		4/26/67	588
		5/26/67	1,500
		6/28/67	614
	San Jeronimo Acazulco	1/18/67	853
		4/11/67	932
		6/14/67	875
	San Mateo Atarasquillo	1/25/67	231
		3/15/67	1,131
		4/19/67	668
		5/23/67	1,142
		6/21/67	725
	San Pedro Atlapulco	3/8/67	1,693
		5/17/67	940

Table 7. Gross beta radioactivity and strontium-90 in foods, Mexico, 1961–1967

Food and station	Harvest date	Gross beta radioactivity (pCi/kg) dry base	Strontium-90 (pCi/kg) dry base
Beans:			
Ganajuato	61/62	6,820	<1
Zacatecas	62/63	3,870	12.5±7.2
	64/65	3,920	<1
Chihuahua	64/65	10,050	4.5±1.3
Durango	66/67	9,400	15.4±1.5
Corn:			
Durango	64/65	4,925	<1
San Luis Potosí	66/67	4,654	<1
Fish:			
Mazatlán and Topolobampo	4/28/67	1,275	<1

Table 8. Radiochemical analysis of sea water, Mexico, January-June 1967

Station	Date (1967)	Suspended solids (pCi/liter)	Beta radioactivity in insoluble sulfides (pCi/liter)	Beta radioactivity in insoluble carbonates (pCi/liter)	Beta radioactivity in soluble carbonates (pCi/liter)
Ensenada	February	0.22±0.02	6.55±0.17	2.00±0.34	80± 6
Mazatlán	February	.16± .02	1.80± .18	3.08± .65	179± 6
Salina Cruz	February	.1	.13± .01	6.66± .01	198±15
Puerto Progreso	June	.1	4.54± .28	3.48± .28	32±18
Puerto Vallarta	June	.14± .03	3.96± .05	4.09± .65	386±39
Veracruz	June	.1	1.99± .9	2.51± .6	283±12

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(*1*) NULMAN, R. M. and M. VASQUEZ BARETE. Radioactivity in the Mexican environment. Radiol Health Data Rep 9:495–501 (September 1967).

Strontium–90 in Human Bone,[1] July–September 1967

National Center for Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium–90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

[1] Period during which death or surgical procedure occurred.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, July-September 1967—Continued

Region and State of residence	Bone type [a]	Age (years) [b]	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
N. Y:	V	01	M	64.2 ± 9.4 [c]	26.6	2.41
Mass:	V	03	M	129.0 ± 9.6	22.8	5.65
Mass:	V	04	F	135.0 ± 14.0	37.1	3.63
Mass:	V	05	M	60.7 ± 8.2	28.5	2.12
Vt:	V	06	M	151.0 ± 9.5	33.5	4.50
Conn:	V, R	07	M	79.5 ± 11.0	28.7	2.77
Conn:	A	07	M	132.0 ± 13.0	33.4	3.95
Vt:	V	08	F	98.2 ± 10.0	35.9	2.73
N. J:	V, R	11	F	79.1 ± 8.4	36.0	2.19
Mass:	V	12	F	80.7 ± 11.0	40.6	1.98
Conn:	V	12	M	37.3 ± 6.9	18.0	2.07
N. Y:	V	12	F	112.0 ± 9.3	48.7	2.29
Conn:	V	13	F	181.0 ± 10.0	49.0	3.69
N. Y:	V	15	F	84.1 ± 8.0	43.8	1.92
Vt:	V	16	M	136.0 ± 11.0	46.3	2.93
N. Y:	V	16	M	248.0 ± 14.0	66.0	3.75
Pa:	V	18	F	115.0 ± 10.0	51.0	2.25
Conn:	V	18	F	216.0 ± 18.0	51.3	4.21
N. Y:	V	18	M	97.7 ± 7.9	41.0	2.38
Vt:	V	19	M	169.0 ± 13.0	47.0	3.59
Conn:	V	19	F	83.8 ± 9.2	39.8	2.10
N. Y:	V	19	M	160.0 ± 12.0	65.1	2.45
Vt:	V	20	F	123.0 ± 13.0	66.9	1.83
N. Y:	V	20	M	84.2 ± 7.9	31.1	2.70
Vt:	V	21	M	112.0 ± 13.0	53.8	2.08
Conn:	V, R	23	F	107.0 ± 11.0	46.9	2.28
Mass:	V	24	M	85.6 ± 7.0	35.4	2.41
N. Y:	V	24	M	126.0 ± 12.0	60.3	2.08
N. Y:	V	24	M	53.7 ± 11.0	40.8	1.31
Southeast:						
Ga:	V	00	M	196.0 ± 18.0	28.5	6.87
Ga:	V	03	F	79.4 ± 12.0	24.3	3.26
N. C:	V	05	M	167.0 ± 15.0	23.5	7.10
Md:	V	05	F	99.6 ± 12.0	34.5	2.88
N. C:	V	07	M	175.0 ± 15.0	19.0	9.21
S. C:	V	13	M	104.0 ± 11.0	32.9	3.16
S. C:	V	16	M	158.0 ± 12.0 [c]	39.4	4.01
Md:	V	16	F	182.0 ± 14.0	62.2	2.92
Md:	V	17	M	140.0 ± 20.0	52.9	2.64
Ga:	V	17	F	105.0 ± 11.0	49.7	2.11
S. C:	V	18	M	156.0 ± 13.0	48.5	3.21
S. C:	V	18	M	77.2 ± 8.0	31.6	2.44
S. C:	V	20	M	157.0 ± 12.0	52.7	2.97
Md:	V	20	M	148.0 ± 13.0	55.7	2.65
S. C:	V	20	M	110.0 ± 9.1	50.1	2.19
Md:	V	20	M	80.0 ± 10.0	42.8	1.88
Md:	V	20	M	84.5 ± 12.0	51.6	1.63
Md:	V	20	M	155.0 ± 10.0	48.8	3.17
Md:	V	22	M	131.0 ± 12.0	50.8	2.57
Ga:	V	22	F	117.0 ± 11.0	60.1	1.94
Md:	V	23	M	73.0 ± 7.2	53.4	1.36
Md:	V	23	M	79.3 ± 7.7	46.4	1.70
Md:	V	23	M	146.0 ± 12.0	57.1	2.55
Ga:	V	23	F	108.0 ± 12.0	52.8	2.04
Md:	V	23	M	137.0 ± 12.0	58.8	2.32
Md:	V	24	M	91.7 ± 10.0	54.3	1.68
Md:	V	24	M	73.2 ± 8.9	51.3	1.42
Md:	V	24	M	74.6 ± 10.0	70.8	1.05
Md:	V	24	M	126.0 ± 10.0	60.0	2.10
Md:	V	24	M	97.8 ± 12.0	56.3	1.73
Central:						
Wisc:	V	00	M	39.2 ± 11.0	27.3	1.43
Wisc:	V	01	M	131.0 ± 11.0	26.7	4.90
Wisc:	V	01	F	108.0 ± 15.0	31.9	3.38
Wisc:	V	02	F	97.6 ± 16.0	28.2	3.46
Wisc:	V	02	M	171.0 ± 17.0	29.7	5.75
Wisc:	V	03	F	118.0 ± 12.0	30.2	3.90
Iowa:	V	06	M	54.8 ± 7.3	36.2	1.51
Ind:	V	07	F	158.0 ± 16.0	35.6	4.43
Minn:	V	07	F	32.6 ± 8.4	26.6	1.22
Ohio:	V	10	M	100.0 ± 6.4	33.6	2.97
Ohio:	V	12	F	187.0 ± 14.0	63.6	2.94
Minn:	V	13	M	105.0 ± 10.0 [c]	44.3	2.37
Mich:	V	14	M	87.8 ± 10.0	37.0	2.37
Ohio:	V	15	F	72.5 ± 7.9	26.3	2.75
Ohio:	V	17	M	161.0 ± 10.0	51.4	3.13
Ohio:	V	18	M	153.0 ± 14.0	59.2	2.58
Ohio:	V	19	M	102.0 ± 10.0	44.6	2.28
Ohio:	V	19	M	141.0 ± 14.0	58.3	2.41
Mich:	V	21	F	170.0 ± 10.0	52.9	3.21
Ohio:	V	21	M	188.0 ± 16.0	72.6	2.58
Ohio:	V	21	F	159.0 ± 18.0	63.7	2.49
Mich:	V	23	F	112.0 ± 10.0	43.9	2.55
Ohio:	V	25	M	109.0 ± 12.0	56.6	1.92

Table 1. Strontium-90 in human bone, July-September 1967—Continued

Region and State of residence	Bone type [a]	Age (years) [b]	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Delta:						
La:	V	02	M	148.0 ± 12.0	29.7	4.98
La:	V	09	M	72.8 ± 12.0	30.6	2.37
La:	A	12	F	144.0 ± 12.0	45.0	3.20
La:	V	13	M	79.8 ± 11.0	31.6	2.52
La:	V, R	14	F	66.9 ± 7.4	57.7	1.15
La:	V	15	M	62.3 ± 9.7	39.8	1.56
La:	V	21	M	117.0 ± 9.7	63.5	1.84
Northwest:						
Ore:	V	00	F	62.9 ± 7.2	58.0	1.08
Ore:	V	01	F	98.9 ± 7.6	54.9	1.80
Ore:	V	15	F	199.0 ± 15.0	62.4	3.18
Wash:	V	18	M	111.0 ± 9.8	44.3	2.50
Ore:	V	23	F	257.0 ± 17.0	50.3	5.10
Ore:	V	23	F	72.9 ± 7.9	45.1	1.61
Southwest:						
Tex:	V	00	F	153.0 ± 20.0	38.3	3.99
Tex:	V	02	F	52.1 ± 8.2	19.8	2.63
Calif:	V	06	M	36.7 ± 5.4	53.8	0.68
Tex:	FO	12	M	98.6 ± 11.0	53.4	1.84
Tex:	V	19	F	87.6 ± 9.1	52.4	1.67
Tex:	V	19	M	97.6 ± 10.0	36.5	2.67

[a] Type of bone: V, vertebrae; R, rib; FO, foot, A, arm.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium–90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the third quarter (July–December) of 1967 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium–90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966	September 1967
January–March 1967	June 1968
April–June 1967	September 1968

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Strontium–90 in Human Vertebrae, 1967[1]

Health and Safety Laboratory
Atomic Energy Commission

Since 1960, measurements of the strontium–90 content of foods and estimates of the daily intake of strontium–90 at New York City, Chicago, and San Francisco have been made by the Health and Safety Laboratory (HASL). Since 1961, measurements of the strontium–90 content of human vertebrae obtained from HASL by cooperating pathologists at the three cities have also been made. Data obtained from these programs have been used to construct models that attempt to explain the variation of strontium–90 concentrations in bone with age and time. The main purpose of the work is to provide estimates of the radiation dose to man that has resulted from the fallout from nuclear weapons tests. In attempting to construct the models it has become apparent that there are serious gaps in our knowledge of mineral metabolism especially that of children. The survey data have therefore been used, at times, to gain some insight into the metabolism of strontium by children. This approach is very difficult because of the small numbers of specimens that are available and the absence of an exact knowledge of the diet of the children from whom specimens were obtained. Because it is unlikely that much direct experimental data from tracer studies on children will ever be available, we will be forced to rely on the indirect evidence from survey results to construct our models.

A listing of the results obtained as part of this program through 1964, along with an interpretation of the data was given earlier (*1*). Results of the analyses of samples obtained in 1965 and 1966 were previously reported (*2*, *3*). Results of the analyses of samples obtained during 1967 are summarized in table 1 and are shown graphically in figure 1. Results of individual analyses are listed in tables 2 and 3.

Table 1. Strontium–90 to calcium ratios in human vertebrae

Age	New York City (pCi ^{90}Sr/g Ca)	San Francisco (pCi ^{90}Sr/g Ca)
<1 mo	——	0.87 (27)
1 mo–1 yr	[a] 4.14 (9)	1.57 (19)
1–2	3.24 (5)	1.65 (3)
2–3	3.21 (5)	——
3–4	3.15 (3)	1.12 (2)
4–5	3.98 (4)	1.59 (2)
5–6	3.70 (2)	1.29 (3)
6–7	2.57 (1)	1.28 (1)
7–8	3.23 (5)	1.22 (2)
8–9	——	1.28 (2)
9–10	——	——
10–11	3.02 (2)	——
11–12	2.28 (2)	——
12–13	——	——
13–14	——	1.40 (1)
14–15	2.84 (2)	1.68 (2)
15–16	3.36 (2)	——
16–17	——	——
17–18	3.08 (4)	——
18–19	2.63 (9)	——
19–20	1.83 (2)	——
20–30	1.98 (12)	——
30–40	1.93 (8)	——
40–60	1.82 (20)	——
> 60	1.73 (14)	——

[a] Number in parentheses indicates number of specimens.

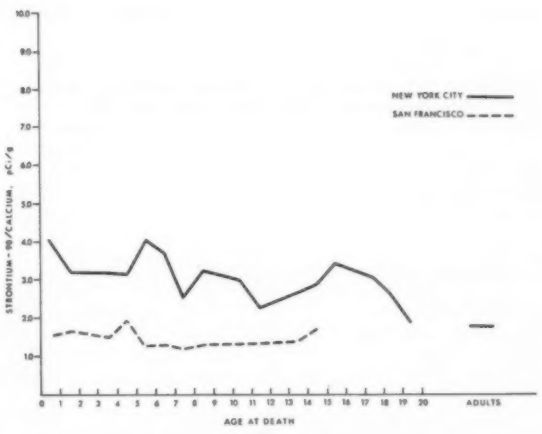

Figure 1. Strontium–90 to calcium ratios in human vertebrae during 1967

The pattern of strontium–90 concentrations in bone found in the 1967 specimens is not in conformity with those patterns previously seen.

[1] Material authored by Mr. J. Rivera, from Fallout Quarterly Summary Report, HASL–197, July 1, 1968. Available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va. 22151.

Table 2. Strontium–90 to calcium ratios of human vertebrae New York City residents, 1967

Age at death	Month of death	pCi ^{90}Sr/g Ca
7 months	7,10,12	[a] 4.55(3)
2 months	4,5,5,3,1,2	3.93(6)
1– 2 years	11	[b] 3.67
1– 2	4,9	3.21(2)
1– 2	11,12	3.05(2)
2– 3	5,10	3.32(2)
2– 3	8	3.08
2– 3	10	3.11
3– 4	5,7	2.89(2)
3– 4	2	3.67
4– 5	2,5	5.04(2)
4– 5	3,9	2.92(2)
5– 6	3,6	3.70(2)
6– 7	11	2.57
7– 8	3	3.03
7– 8	4	3.44
7– 8	7	4.02
7– 8	2	2.16
7– 8	11	3.46
10–11	3	3.40
10–11	7	2.61
11–12	7	3.06
11–12	10	1.49
14–15	6	3.65
14–15	8	2.03
15–16	9	3.51
15–16	8	3.21
17–18	6	2.32
17–18	4	3.43
17–18	8	3.46
17–18	9	3.11
18–19	7	1.92
18–19	3	2.73
18–19	7	2.54
18–19	7	2.40
18–19	7	2.90
18–19	7	4.19
18–19	3	2.67
18–19	9	2.13
18–19	9	2.21
19–20	6	2.03
19–20	9	1.62
20	5	2.54
20	2	2.24
20	7	1.96
22	5	2.32
22	7	1.88
22	5	1.46
23	4	1.76
24	7	1.89
24	5	1.76
25	1	2.03
28	9	2.08
28	2	1.88
30	6	2.07
30	7	1.49
31	5	2.25
33	6	2.13
33	5	1.80
35	5	1.68
35	6	2.19
39	6	1.79
40	7	1.80
41	8	1.40
41	9	1.74
45	12	1.67
45	5	1.79
46	5	1.94
47	5	1.49
48	6	1.78
49	7	2.64
50	7	1.83
51	1	1.46
52	10	2.94
52	5	1.56
53	2	1.54
54	5	2.75
55	1	1.70
55	4	1.94
56	1	1.39
56	6	1.52
58	1	1.51
60	6	1.67
63	7	1.77
67	5	1.56
68	1	0.77
70	3	2.00
70	7	1.71
71	3	1.99
71	6	1.42
72	4	1.76
73	4	2.04
77	8	2.86
82	9	1.57
83	3	1.33
83	6	1.82

[a] Number in parentheses indicates number of specimens.
[b] Only one specimen.

Table 3. Strontium–90 to calcium ratios of human vertebrae, San Francisco residents, 1967

Age at death	Month of death	pCi ^{90}Sr/g Ca
1 week	1,1,1,1,2,2	[a] 0.88(6)
1	3,4,4,9,9	.98(5)
1	5,5,6,7,7,7	.90(6)
1	8,8,8,8,8	.78(5)
1	8,8,9,10,10	.82(5)
1 month	1,1,2,3,4	1.18(5)
1	6,9	.66(2)
3	2,5,6,8,8,10	1.63(6)
8	2,3,7,9,10,12	2.15(6)
1– 2 years	2,3,7	1.65(3)
3– 4	1	[b] 1.74
3– 4	10	1.29
4– 5	3	2.21
4– 5	6	1.57
5– 6	3	1.51
5– 6	10	1.15
5– 6	10	1.21
6– 7	3	1.28
7– 8	1	.71
7– 8	4	1.73
8– 9	2	1.22
8– 9	7	1.34
13–14	5	1.40
14–15	9	1.65
14–15	8	1.71

[a] Number in parentheses indicates number of specimens.
[b] Only one specimen.

The peak in strontium–90 concentrations usually seen in young children was not evident; the concentrations were, however, as expected higher than those found in specimens from adults. Strontium–90 concentrations from New York City residents were about three times higher than corresponding specimens obtained in San Francisco. This persistent relative difference reflects the fact that strontium–90 intakes in New York City have been continually about three times as great as the intakes in San Francisco as can be seen from figure 2 where the results of our diet surveys are shown graphically.

Infants

A relatively large number of specimens were obtained in San Francisco from infants who died after less than 1 week of life. The average

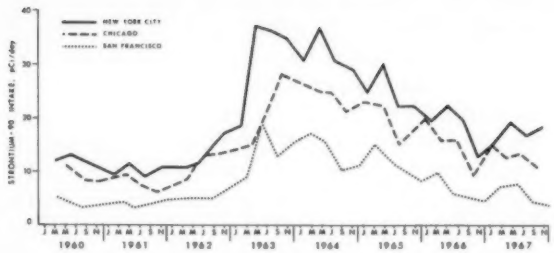

Figure 2. Daily intake of strontium–90

strontium–90 to calcium ratio found in these specimens was 0.87 pCi/g Ca. Since the average diet of mothers from the San Francisco area was probably not greater than about 7 pCi/g Ca (figure 2), the mother's diet-fetal bone observed ratio is probably not less than 0.12. This result is in general agreement with the hypothesis that placental discrimination is about 0.25 and hence the total discrimination from mother's diet to fetal bone is expected to be $0.5 \times 0.25 = 0.12$.

The expected concentrations of strontium–90 in the bones of children who died during the first year of life were calculated using the relation derived in a prior publication (*3*):

$$X_{0-1} = 0.065\, Z_m + 0.15\, Z$$

where X_{0-1} is the average strontium–90 to calcium ratio of the bones of infants up to 1 year of age. Z_m is the average strontium–90 to calcium ratio of the mother's diet for the 3-month period prior to birth and Z is the average strontium–90 to calcium ratio of the child's diet during the first year of life. The results along with the observed values are shown in table 4. The agreement between predicted and observed results parallels what has been obtained in the past.

Table 4. Predicted and observed ratios of strontium–90 to calcium in infants

	pCi ^{90}Sr/g Ca	
	Predicted	Observed
New York City	3.4	4.1
San Francisco	1.2	1.6

Adults

A formula derived in (*1*) for calculating the expected strontium–90 to calcium ratio of vertebrae from adults is:

$$X_n = 0.9\, X_{n-1} + 0.02\, Z_{n-1}$$

where X_n is the strontium–90 to calcium ratio of the vertebrae at the beginning of year 'n', X_{n-1} is the ratio at the beginning of year 'n–1' and Z_{n-1} is the strontium–90 to calcium ratio of the diet during the year. In deriving this expression it was assumed that the rate of replacement of calcium in vertebrae is 8 percent per year and that the bone-diet observed ratio was 0.25.

Since the observed bone concentrations of adults are average values obtained from people who died at different months of the year, the expected concentration for New York City residents at the middle of the year was calculated. The result was:

$$X_n = 0.9\ (2.07) + 0.02\ (17) = 2.20 \text{ pCi/g Ca}$$

The observed average value was 1.85 pCi/g Ca.

Children

The pattern of the contamination of children's bones with strontium–90 can be seen in tables 5 and 6.

Table 5. Average strontium–90 to calcium ratio in children's bones (New York City)

Age range	1961	1962	1963	1964	1965	1966	1967
0–4	2.83	3.06	5.13	5.50	6.45	4.98	3.44
4–12	1.38	1.70	2.02	3.46	3.50	3.66	3.13
12–20	1.28	1.56	2.09	2.98	3.54	2.93	2.75

Table 6. Average strontium–90 to calcium ratio in diet (New York City)

	1961	1962	1963	1964	1965	1966	1967
Yearly	10	13	31	32	25	19	17
	1960–1961	1961–1962	1962–1963	1963–1964	1964–1965	1965–1966	1966–1967
Mid-year to mid-year	11	11	21	34	16	22	17

From these data one can see that the increase in diet levels from 1962 to 1963 produced a

sharp increase in bone strontium–90 concentrations of young children and a lesser increase in the bone levels of older children. The 1967 bone levels of young children, however, are much lower than those observed in 1966 although the diet levels were practically the same for the 2 years. The significance of these changes in the light of the models proposed by Fletcher, Loutit and Papworth (*4*), Beninson et al (*5*), and this laboratory (*6*) may be the subject of a future report.

When this formula was applied to calculate expected values for 1966, the result was 2.35 pCi/g Ca as compared to the observed value of 2.07 pCi/g Ca.

If the bone-diet observed ratio is 0.25 then one would expect bone levels to continue to increase until they reach the equilibrium point where they have a strontium–90 to calcium ratio equal to one-fourth that of the diet. Apparently, however, during 1966 and 1967 vertebrae from adults had declining strontium–90 to calcium ratios. Although admittedly the scatter of values about the mean strontium–90 to calcium ratio is so great as to preclude granting statistical significance to this decline, it appears that the model may have to be revised, and the possibility that the previously achieved good agreement between observed and calculated strontium–90 bone levels is fortuitous, or at best, works only when diet strontium–90 levels are increasing.

Probability distribution

A number of investigators (*7*, *8*, *9*) have pointed out that when the frequency distribution of bone strontium–90 to calcium ratios are plotted on arithmetic probability paper and on logarithmic probability paper the 'fit' appears to be better on the logarithmic paper. They conclude therefore, that geometric means and standard deviations should be given to characterize bone strontium–90 to calcium ratios of populations rather than arithmetic means and standard deviations. This conclusion is important because if the distribution is log normal then a larger fraction of the population will have strontium–90 body burdens 'n' times the mean than would be calculated assuming a normal distribution. A criticism of this conclusion is that the "eyeball goodness of fit" test is not always reliable. It should also be pointed out that in most cases the samples for which frequency distributions were calculated were not homogeneous. If the sample population had included a non-random number of children or consisted of specimens obtained in a non-random way from areas where the diet strontium–90 to calcium ratios were quite different, adventitiously bizarre distributions might be expected.

To obviate some of these difficulties, specimens were obtained from 42 individuals who were over 30 years of age at death and who could reasonably be assumed to have lived in New York City for a considerable length of time just prior to death. The results of the analyses of the 42 specimens were averaged and the standard deviation from the mean was calculated. Using this mean and standard deviation, a straight line was drawn on arithmetic probability paper. The points for the observed cumulative frequency distribution were then plotted on the graph which is shown in figure 3. A similar procedure was used to calculate the geometric mean and geometric standard deviation of the population and to draw the straight line on logarithmic probability paper shown in the bottom of figure 3. As before, the observed cumulative frequencies were also indicated as points on the graph.

Although it appears that the 'fit' is better on the log-normal paper, it was not appreciably better. A more objective test of the "goodness of fit" of the data to the two hypothetical distributions was attempted by applying the non-parametric Kolmogorov-Smirnov (*10*) test. The result was that at a 5 percent level of significance the hypothesis that the sample was drawn from a normal distribution could not be rejected. The test also showed that the hypothesis of the sample being drawn from a log-normal distribution could not be rejected. Although according to Massey (*11*) the K-S test is more powerful than the Chi square test, the test was quite weak. Thus, the assertion that the distribution is normal may be wrong 68 percent of the time while the assertion that the sample was drawn from a log-normal distribution may be wrong 83 percent of the time.

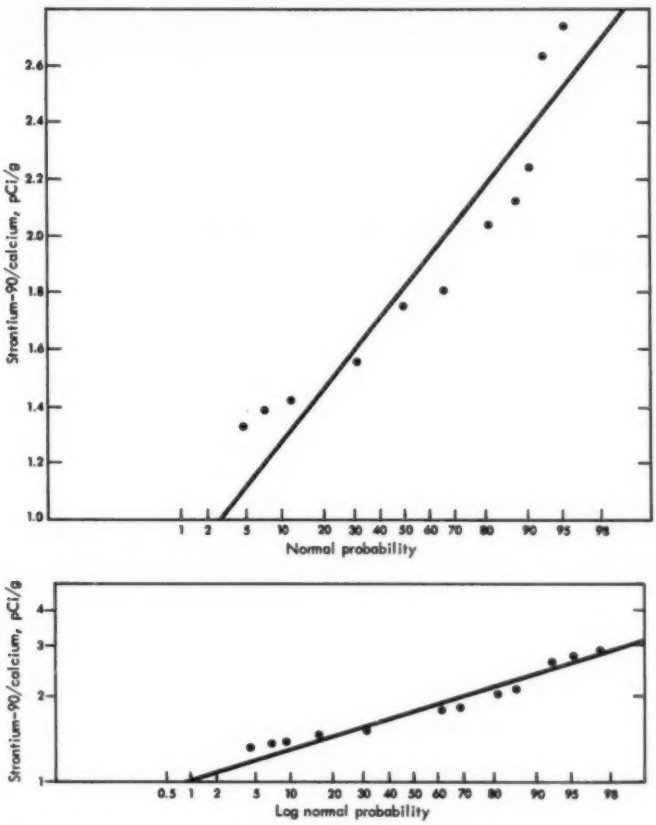

Figure 3. Frequency distribution of strontium-90/calcium ratios in adult vertebrae, New York City, 1967

Conclusions

From this exercise it is concluded that it is quite difficult to prove that bone strontium–90 to calcium ratios from a geographically homogeneous sample of adults are log-normally distributed. It is probably justified, however, to assume a long-normal distribution for radiation hazard evaluations.

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the National Reactor Testing Station and Oak Ridge Area.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. National Reactor Testing Station[2] July–December 1967

Health and Safety Division
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the second half of 1967 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the levels defined as thresholds of concern by the Federal Radiation Council (FRC). The radiation protection standards used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium–226 or radium–228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate activity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water, wheat and milk are collected routinely at stations shown in figure 1. The results of the analyses performed on the air, water and milk samples are shown in table 1.

[2] Summarized from "Environmental Monitoring Report No. 21, July–December and Annual Summary for 1967," U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

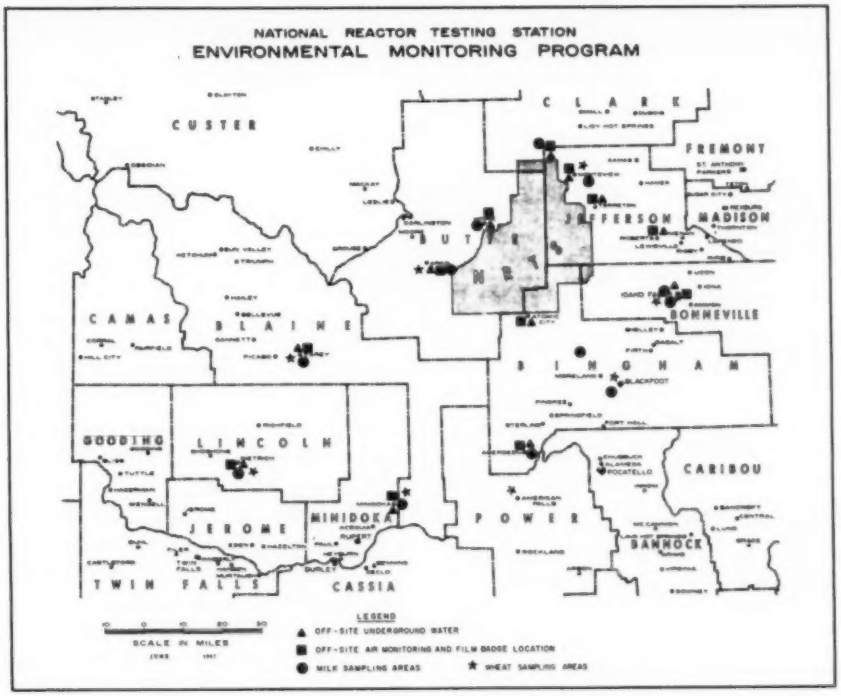

Figure 1. Environmental monitoring stations, National Reactor Testing Station

Offsite water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly from those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map, plus the onsite samples provide adequate information on the underground water leaving the NRTS. During the second half of 1967, one sample was collected from each of 12 sampling stations. The average concentrations of alpha and beta particle emitters were less than 3 percent and 7 percent of the respective AEC standards. The alpha radioactivity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define possible sources of contamination. During the summer one additional sampling station was added to the 22 regular stations. A total of 468 samples were analyzed in 1967 and 263 for the last 6 months of 1967. These samples are collected on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta-particle emitters were no more than 0.1 percent and 0.2 percent of their respective AEC standards.

Air monitoring

During the last half of 1967, 206 air samples were collected and evaluated for airborne alpha-particle emitters. A gross alpha-particle determination was made on filter paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products

Table 1. Environmental monitoring data for NRTS, July–December 1967

Type of sample and units	July–December 1967						AEC radiation protection standard
	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	
Offsite underground water, (pCi/liter)	12	Semiannual	Alpha	3	4	<3	100
			Beta	6	10	<7	100
Onsite production well water, (pCi/liter)	22	Biweekly	Alpha	3	7	<4	3,000
			Beta	6	36	<8	3,000
Offsite air, (pCi/m³)	12	Continuous	Beta-gamma	1.6	26	<4	100
			Iodine-131	3.6	15	<4	100
Offsite milk, (pCi/liter)	12	Monthly	Iodine-131	20	20	<20	100
			Strontium-90	1.5	7	<4	200
Offsite area monitoring badges, (mR)	12	Semiannual	Gamma	10	80	<39	170/yr

of radon and thoron. The filter paper samples were counted for alpha-particle emission by scintillation counters. The average measured concentrations of alpha radioactivity in air was .002 pCi/m³ or less than 7 percent of the AEC standard. The radiation protection standard used is that for uncontrolled areas and for gross alpha radioactivity for which no analyses for specific radionuclides have been made. The alpha radioactivity is attributed primarily to long-lived radioactive elements naturally present in the environment.

Results of the data reported from the 12 offsite radiation telemetry stations indicate that the average concentrations of gaseous iodine–131 and particulate gross beta radioactivity in the atmosphere were less than 4 percent of the AEC radiation protection standards.

Offsite milk monitoring

Routine analyses of iodine–131 and strontium–90 concentrations in milk continued during the second half of 1967. As indicated in table 1, the average iodine–131 levels do not exceed 21 percent of the permissible concentrations derived from FRC guides. Strontium–90 concentrations were less than 3 percent of the AEC standard.

Gamma radiation levels

Seminannual measurements of external gamma radiation levels were made with thermoluminescent dosimeters (TLD) at 12 offsite locations during the second half of 1967.

Natural background radiation levels at TLD locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100–150 mR/yr. This indicates that NRTS operations have not contributed significantly to the environmental radiation levels of the surrounding areas.

Wheat monitoring

Eight wheat samples were collected from southeastern Idaho during the 1967 grain harvest. The strontium–90 levels ranged from 1 to 17 pCi/kg (dry weight) with an average of 8 pCi/kg. Analysis for cesium–137 showed an average concentration of 21 pCi/kg. Routine analysis of the wheat samples did not detect the presence of manganese–54. When the wheat concentrations are compared to the RCG value for water, it is evident that wheat does not contribute a significant amount to the local radiation dose.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December and calendar year 1966	September 1967
January–June 1967	March 1968

2. Oak Ridge Area[3] July–December 1967

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex, made up primarily of the Y–12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

[3] Summarized from Environmental Levels of Radioactivity for the Oak Ridge Area, Report Period, July-December 1967. Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 2) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 3). This system provides data to aid in evaluating local conditions and to assist in determining the spread or disposal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 2 and 3. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the July–December 1967 surveillance period, 234 samples were collected from perimeter monitoring stations and analyzed for iodine–131. Of these, the maximum concentration detected was 0.22 pCi/m³, the minimum was less than 0.010 pCi/m³ and the average was 0.02 pCi/m³. The radiation protection

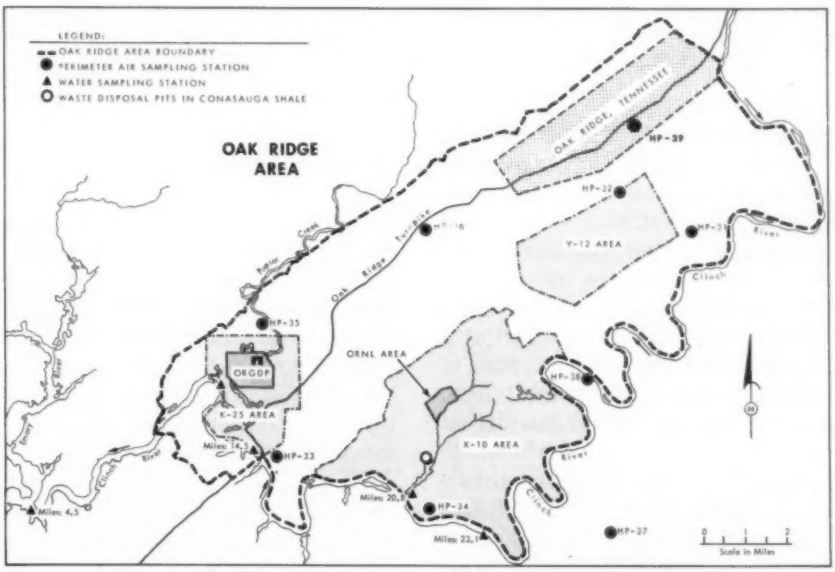

Figure 2. Oak Ridge area environmental sampling locations

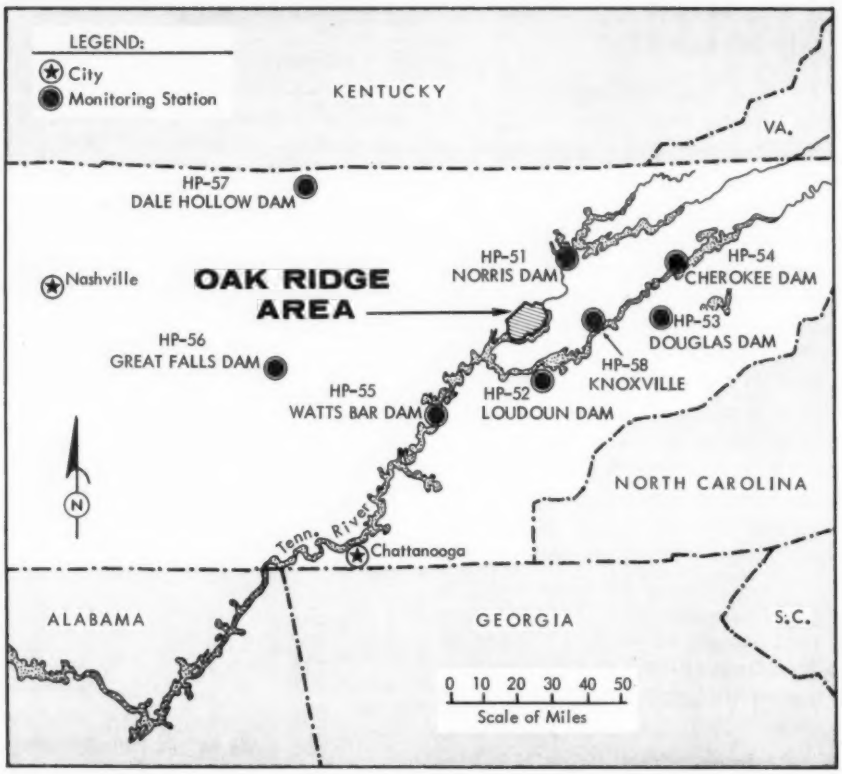

Figure 3. Remote air monitoring stations, Oak Ridge area

standard specified in the AEC Manual for iodine–131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine–131 and strontium–90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold; first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine–131 and strontium–90 detected in raw milk samples during the period are given in table 4.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Table 2. Long-lived gross beta radioactivity of particulates in air Oak Ridge area, July–December 1967

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average conc. (pCi/m³)	Percent of AEC standard [a]	Station number (figure 2)	Number of samples	Average conc. (pCi/m³)	Percent of AEC standard [a]
HP-31	27	0.036	0.04	HP-51	27	0.031	0.03
HP-32	27	.071	.07	HP-52	27	.029	.03
HP-33	27	.031	.03	HP-53	27	.056	.06
HP-34	27	.039	.04	HP-54	27	.028	.03
HP-35	26	.033	.03	HP-55	26	.024	.02
HP-36	188	.072	.07	HP-56	26	.026	.03
HP-37	27	.023	.02	HP-57	27	.025	.03
HP-38	27	.058	.06	HP-58	27	.035	.04
HP-39	27	.038	.04				
Average		0.045	0.05	Average		0.032	0.03

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m³.

Table 3. Long-lived gross alpha radioactivity of particulates in air Oak Ridge area, July–December 1967

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average conc. (pCi/m³)	Percent of AEC standard [a]	Station number (figure 2)	Number of samples	Average conc. (pCi/m³)	Percent of AEC standard [a]
HP-31	27	0.002	0.10	HP-51	27	0.002	0.10
HP-32	27	.004	.20	HP-52	27	.002	.10
HP-33	27	.002	.10	HP-53	27	.002	.10
HP-34	27	.002	.10	HP-54	27	.001	.05
HP-35	26	.003	.15	HP-55	26	.002	.10
HP-36	188	.009	.45	HP-56	26	.002	.10
HP-37	27	.002	.10	HP-57	27	.001	.05
HP-38	27	.002	.10	HP-58	27	.003	.15
HP-39	27	.003	.15				
Average		0.003	0.15	Average		0.002	0.10

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m³.

Table 4. Radionuclides in raw milk, Oak Ridge area, July–December 1967

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum [a]	Average
Iodine-131			
Immediate environs	13	<10	5.0
Remote environs	<10	<10	5.0
Strontium-90			
Immediate environs	50	9.0	28
Remote environs	34	14	25

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this Concentration.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta particle emitters, uranium, and the transuranic alpha-particle emitters.

Table 5. Concentrations of major radionuclides in the Clinch River July–December 1967

Radionuclide	Average concentration (pCi/liter)		
	Location on Clinch River [a]		
	Mile: 23.1 [b] (Upstream)	Mile: 20.8 [c] (Outfall)	Mile: 4.5 (Downstream)
Strontium-90	0.4	0.6	1.4
Cerium-144	< .1	< .1	0.2
Cesium-137	< .1	.2	1.4
Ruthenium-106	.2	.4	0.5
Cobalt-60	ND	.2	.7
Zirconium-niobium-95	ND	< .1	.1
Gross beta	.7	8.0	4.4

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] Sampling station moved from Clinch River mile 41.5 to Melton Hill Dam CRM 23.1 about January 1, 1966.

[c] The concentrations at mile 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.

ND, nondetectable.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 5 for the period from July through December 1967.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For both samples, the uranium concentrations were less than 1 pCi/liter the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 2×10^4 pCi/liter.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 6 in terms of mR/hr.

Table 6. External gamma radiation levels [a], Oak Ridge area, July–December 1967

Location	Average exposure rates (mR/hr)
Solway Gate	0.011
Y-12, East Portal	.011
Newcomb Road	.011
Gallaher Gate	.010
White Wing Gate	.011
Five locations	0.011

[a] The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/hr.

Discussion of data

The average air contamination levels for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 2 and 3) were 0.05 percent and 0.03 percent, respectively, of the AEC radiation protection standard for populations in the neighborhood of a controlled area.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.15 percent and 0.10 percent, respectively, of the AEC radiation protection standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine–131 in air in the immediate environs of the plants was 0.020 pCi/m^3. This is approximately 0.02 percent of the AEC radiation standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine–131 in raw milk in the immediate and remote environs of the Oak Ridge area were 5 pCi/liter. This level falls within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium–90 in raw milk in the immediate and remote environs of the controlled area were 28 pCi/liter and 25 pCi/liter, respectively. These levels fall near the lower limit of FRC Range II for transient rates of daily intake of strontium–90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 8 pCi/liter and 4.4 pCi/liter, respectively. These values are 0.67 percent and 0.49 percent of the weighted average AEC radiation protection standards. The average concentration of transuranic alpha particle emitters in the Clinch River at mile 20.8 was 0.11 pCi/liter which is approximately 0.01 percent of the weighted average AEC radiation protection standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.011 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	August 1967
January–June 1967	July 1968

Reported Nuclear Detonations, September 1968

The U.S. Atomic Energy Commission announced that the United States had recorded seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region on September 5, 1968. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Announcements were also made by the U.S. Atomic Energy Commission of two nuclear tests, one of low-intermediate yield (20 to 200 kilotons TNT equivalent) on September 6, 1968 and one of low yield (less than 20 kilotons TNT equivalent) on September 12, 1968. Both were conducted underground by the Atomic Energy Commission at its Nevada Test Site.

A nuclear test of low-intermediate yield (20–200 tons TNT equivalent) was conducted underground September 17, 1968, by the Atomic Energy Commission at its Nevade Test Site as part of the Plowshare Program to develop peaceful uses for nuclear explosions. This test was one of a series to develop nuclear explosives for use in excavation experiments.

The U.S. Atomic Energy Commission also announced a nuclear test of low yield (less than 20 kilotons TNT equivalent) that was conducted underground by the Atomic Energy Commission at its Nevada Test Site on September 24, 1968.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A PILOT SURVEY OF X-RADIATION EMISSIONS FROM COLOR TELEVISION RECEIVERS IN PINELLAS COUNTY, FLORIDA. *Technical Services Branch, National Center for Radiological Health,* Vol. 9, October 1968, pp. 525–530.

A pilot survey was conducted in Pinellas County, Florida, in November 1967 to evaluate methodology and techniques for use in determining the effectiveness of General Electric Company's modification program of color television receivers and in assessing the total radiation mission situation for television sets of all manufacturers. The instrument used was designed by the National Center for Radiological Health to facilitate rapid home surveys. To further document the source, size, shape and intensity of emissions, radiographic films were exposed on selected receivers.

The primary object of this survey was to evaluate the effectiveness of the downward beam modification program. Within the limits of this survey, the General Electric Company's downward beam modification program was found effective. The initial survey determined that 43 of the 148 sets had x-ray emissions in excess of 0.5 mR/hr; after modification, all sets emitted less than 0.5 mR/hr. A second object of the survey was to evolve and test new instruments and new methods of measurement for a future survey of television sets produced by all manufacturrs.

KEYWORDS: Color television receivers, Florida, home surveys, picture tube, radiographic films, regulator tube, x-ray emissions.

A SUMMARY OF THE WASHINGTON, D.C. METROPOLITAN AREA SURVEY OF COLOR TELEVISION RECEIVERS. *Technical Services Branch, National Center for Radiological Health.* Vol 9, October 1968, pp. 531–538.

A survey was conducted by the National Center for Radiological Health (NCRH) during December 1967 and January 1968 with the cooperation of the Electronic Industries Association and individual manufacturers to obtain x-ray emission data from color television receivers owned by Public Health Service employees in the Washington, D.C. area. Radiation measurements, using a survey instrument developed by the NCRH, were made on 1,124 color television sets of various makes and models. Of these sets, 66 emitted x rays at exposure rates in excess of the recommended level of 0.5 mR/hr. The x-rays emissions were reduced to acceptable levels through service adjustments, such as replacement of shunt regulator or rectifier tubes and reduction of the operating high voltage. The survey results are considered to be valid only for the sample of sets examined in the Washington, D.C. area.

KEYWORDS: Color television receivers, home surveys, Washington, D.C., x-ray emissions.

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October 1968

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